Mind Control

-OR-

WHAT A WASTE IT IS TO LOSE ONE'S MIND.

OR NOT TO HAVE A MIND IS BEING VERY WASTEFUL.

HOW TRUE THAT IS.

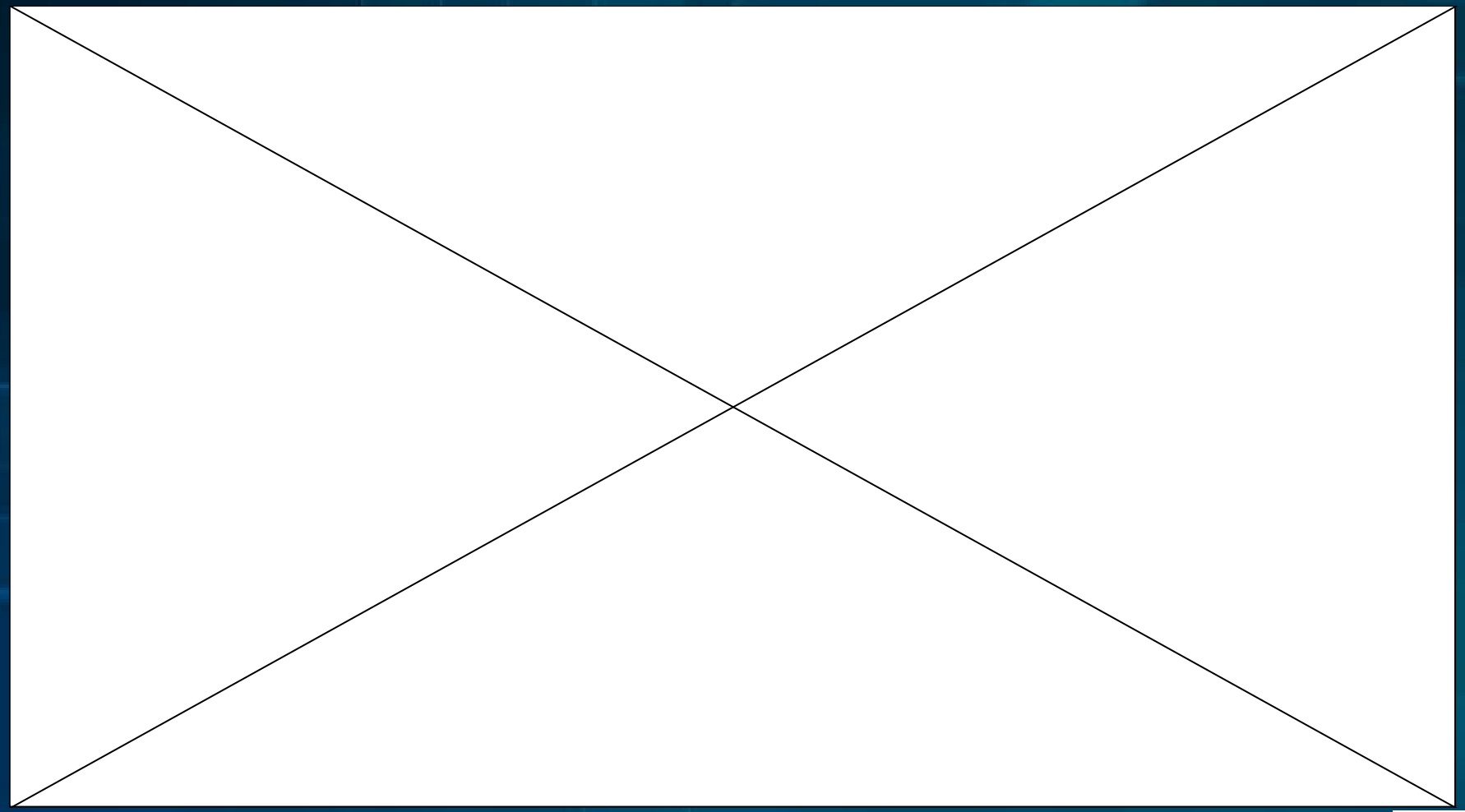
The Question

- Is it *possible* for an outside entity* to control the body and behavior of a higher order organism through direct manipulation of the nervous system?

* *Entity* here is meant to encompass any biological or technological system that is alien to the normal biological operation of the target organism.

As distinct from *Muscle Override*

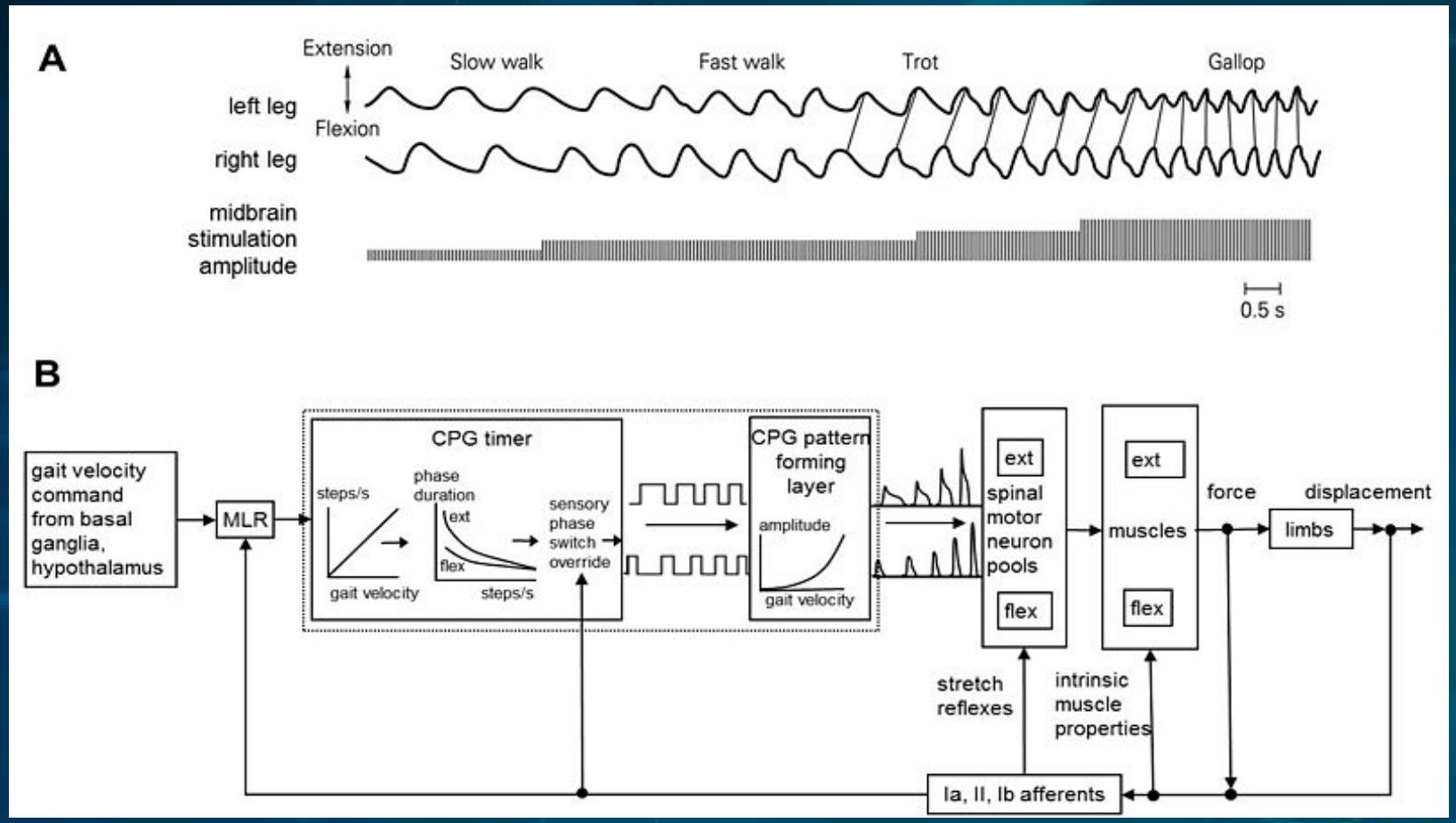
Through direct electrical stimulation, it is clearly possible to control the muscles of a living organism



But...

It turns out that complex activities are... complex

The body distributes computation, even in higher order organisms



Central Pattern Generator used in walking: http://goo.gl/XjT6K

Nature at Work

An emerald cockroach wasp (*Ampulex compressa*) enslaves a much larger cockroach (*Periplaneta americana*).

The wasp injects a neurotoxin into the cockroach's brain, killing off the roach's ability to control its own movement

Doesn't paralyze it entirely.

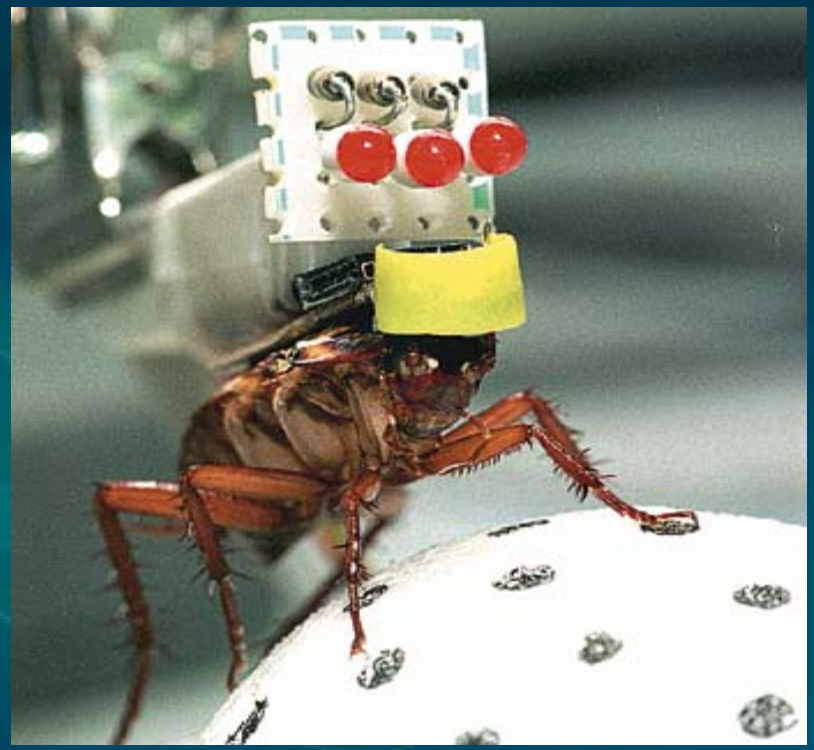
The wasp … grasp[s] the roach's antenna and lead[s] it into a nest before laying an egg in the live cockroach's body.

Permanently incapacitated, the cockroach is unable to escape and is eaten from the inside by the growing wasp larva.

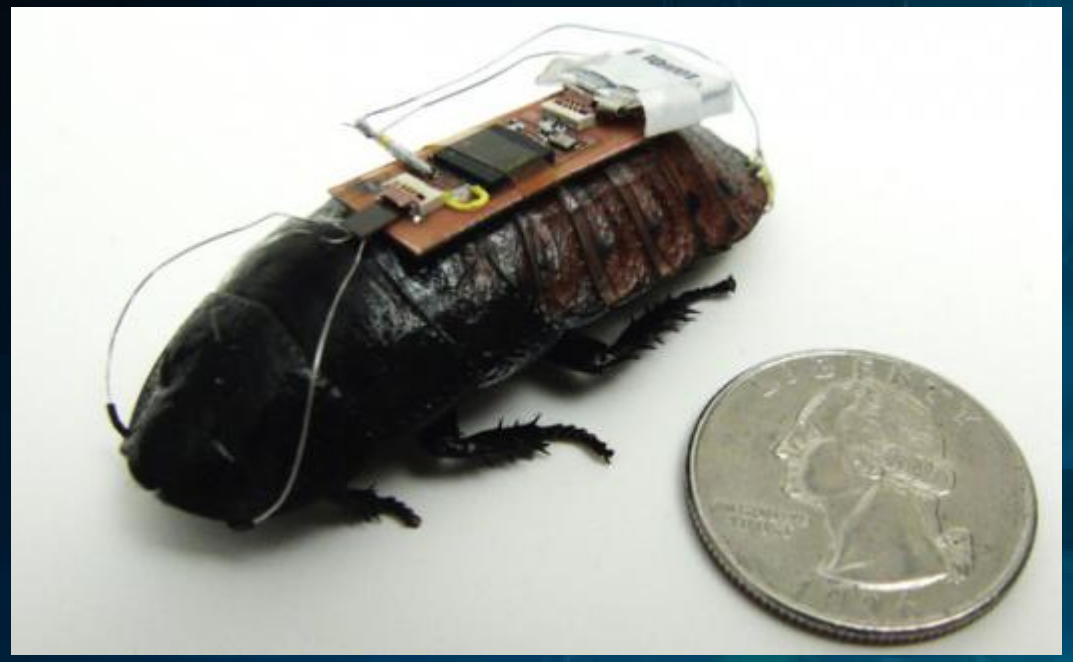
http://www.scientificamerican.com/slideshow.cfm?id=zombie-creatures-parasites

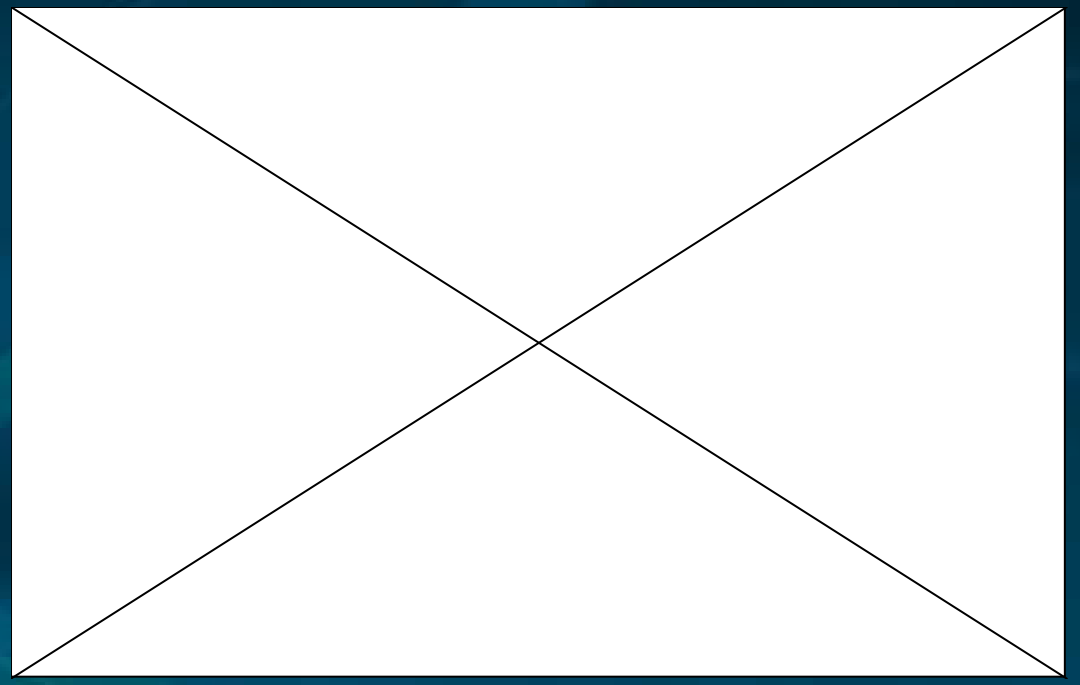
Let's do that!

- University of Tokyo researchers have wired cockroaches for remote control
- Removed wings and antennae, wiring remotely-controlled pulse generators into the antennae sockets
- Roaches become desensitized over time



We'll Never Give Up!



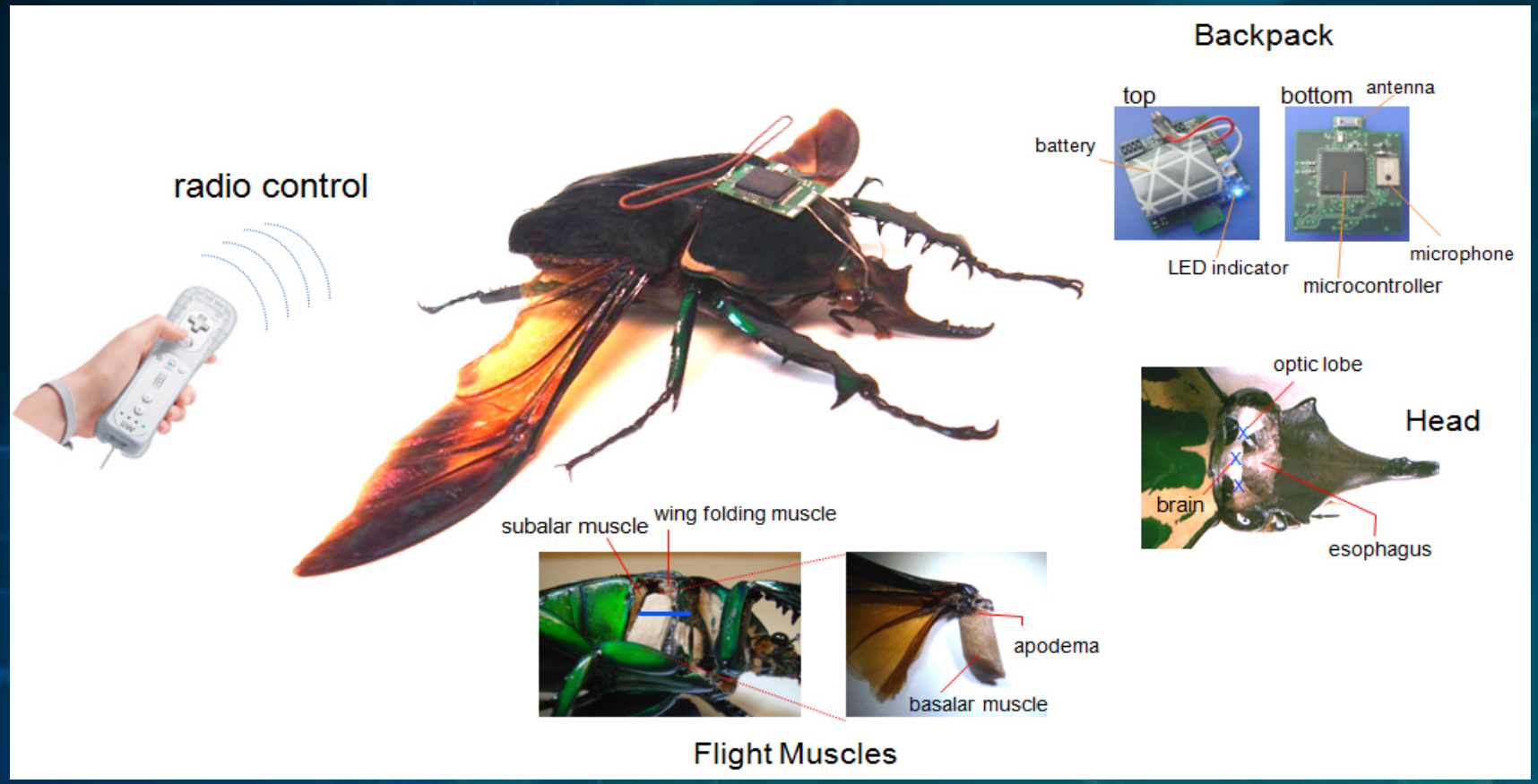


0.7-gram micro-controller fitted to the roach's back
Interfaced to antennae and cerci

"cerci is an organ on the roaches abdomen that senses movement in the air and gives the roach a sense that something is approaching from behind"

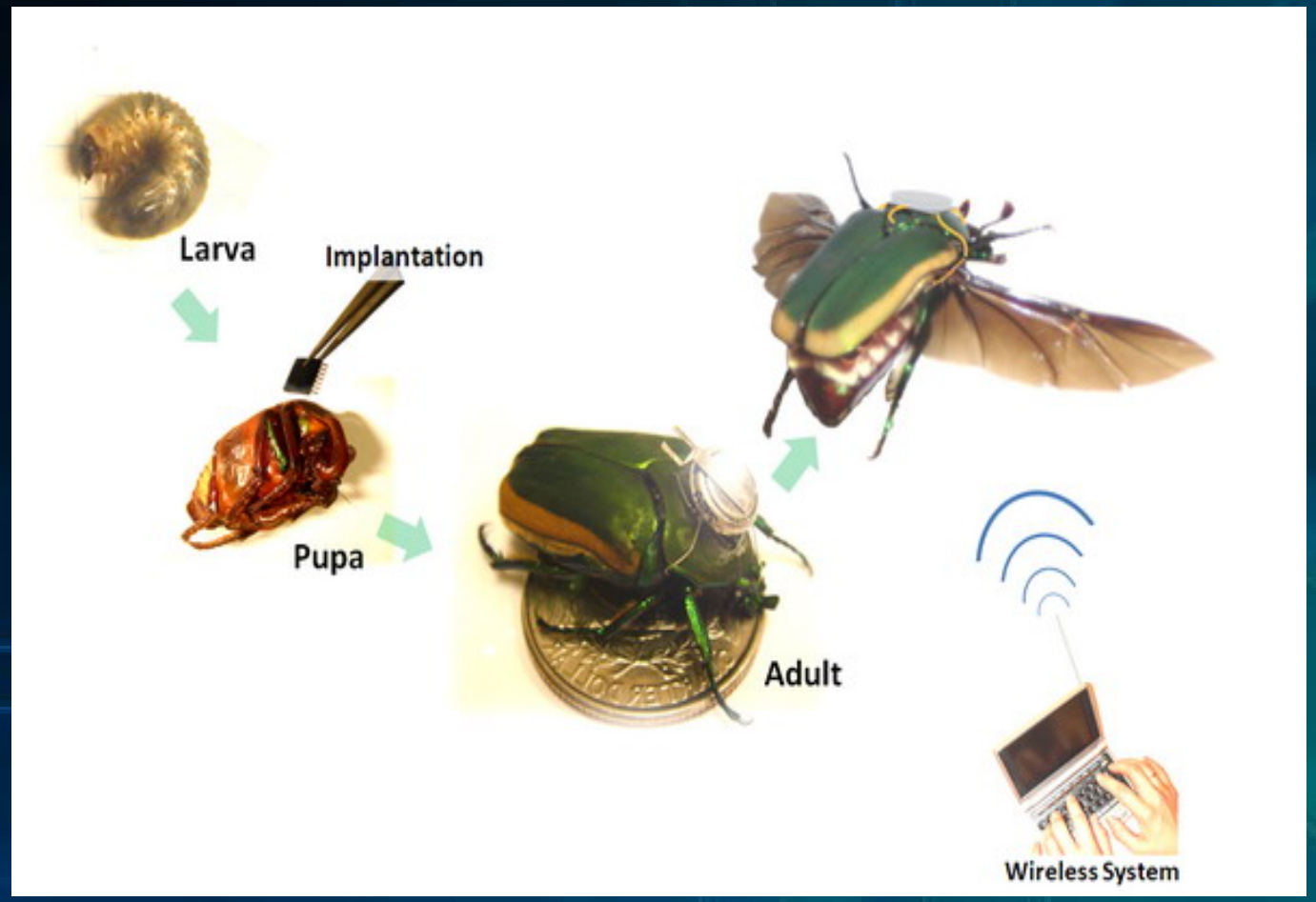
ci: http://goo.gl/emfvzr

More Cyborg Insects



http://www.eecs.berkeley.edu/~maharbiz/Cyborg.html

Cyborg Insects



Parts cost “less than five dollars”

Six electrodes attached to the optic lobes, brain, and wing muscles of the beetle

- Implanted when insect is in pupal stage
- When adult beetle emerges, the electrodes are fully integrated into its body.

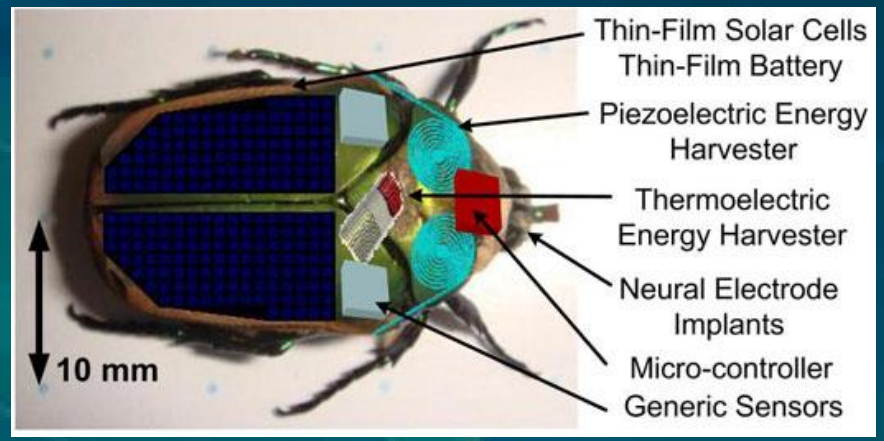
Signals from a transmitter send pulses:

- to the electrodes in the optic lobes to initiate or terminate flight
- to the electrodes in either the left or the right wing to force a turn in that direction

The system both hijacks the natural motor control functions of the beetle and artificially induces physiological change in the insect.

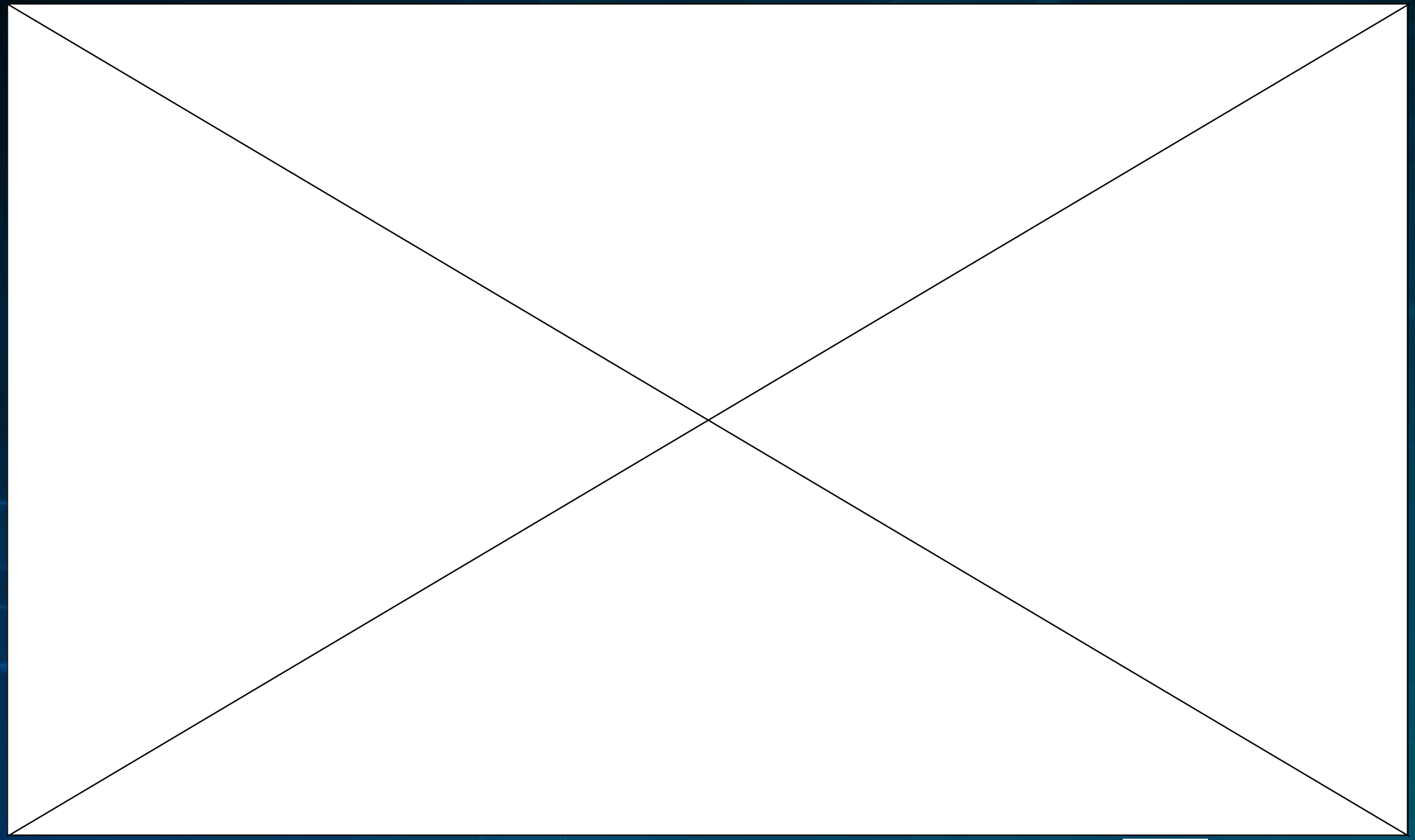
Um… OK? But WHY?

Living cells tend to require less power and complete higher precision movements than "even the most advanced machines"
By combining these cells with mechanical and electrical systems, researchers hope to push beyond current limitations on wholly non-living systems



Applications?

search and rescue
surveillance in difficult to reach locations
self-repairing materials
systems that reconfigure themselves based on environmental factors
replacement tissue for damaged organs.



Perhaps that won't always work...

Because the body is so good at carrying out purposive action, why not directly affect the brain itself?

Either...

Force generation of the high-level commands

Or

Make the organism *want* to do what you want it to.

Is that even *possible*?

Of course it is! Natural Mind Control

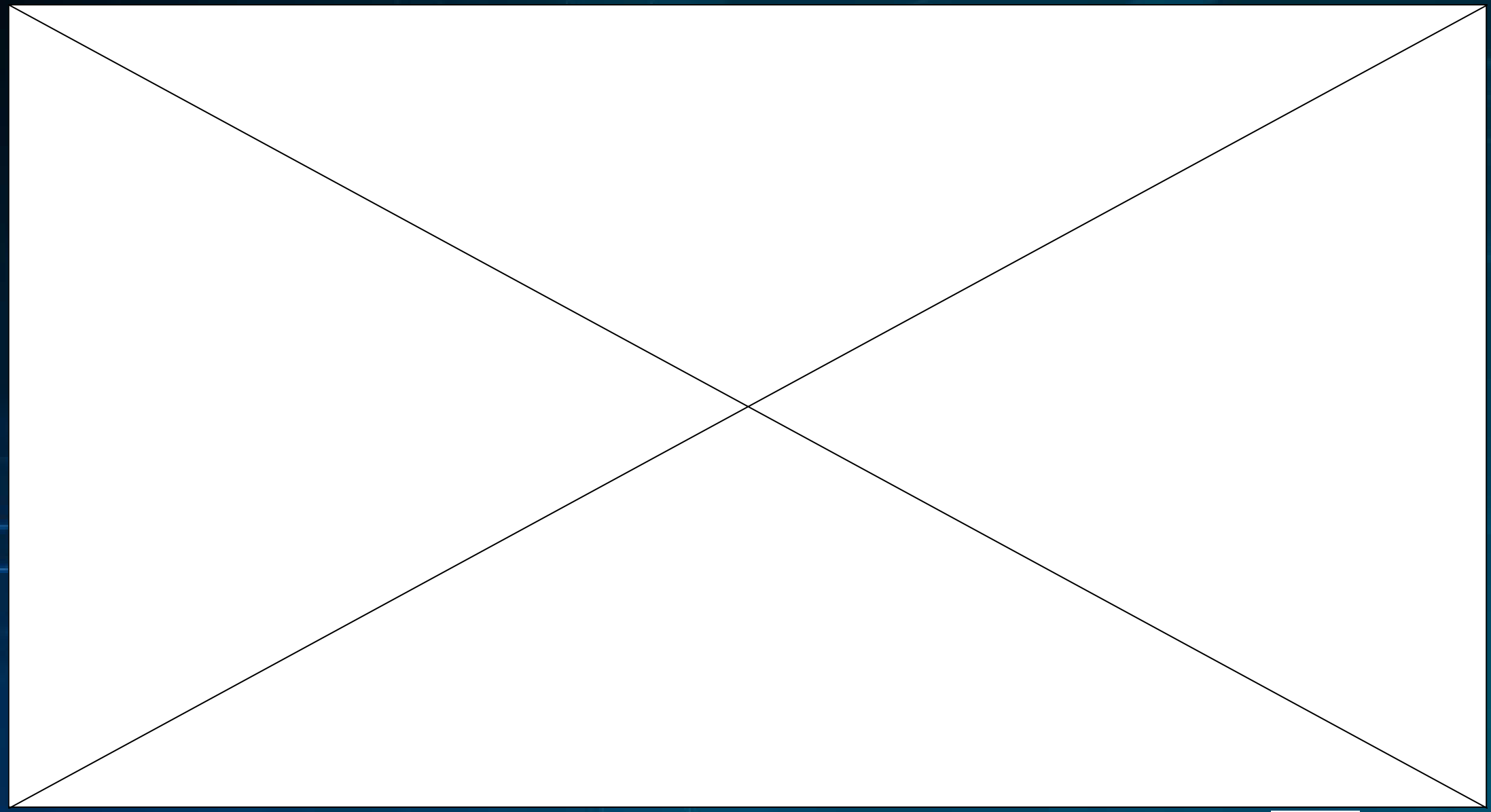
Glyptapanteles

- A parasitic wasp that lays its eggs in the body of a caterpillar.
- Wasps rely on a polydnavirus modified by their own system
- Disables the caterpillar's immune response to allow eggs to grow
- Eggs hatch and feed on the caterpillar, but do not kill it.
- Caterpillar stops developing and spends the rest of its life protecting the wasp larva
- Behavior modified by a toxin produced by the larvae
- Caterpillar even spins its own cocoon around the wasp pupae.

http://www.mentalfloss.com/blogs/archives/25336#ixzz1pet2wYKr

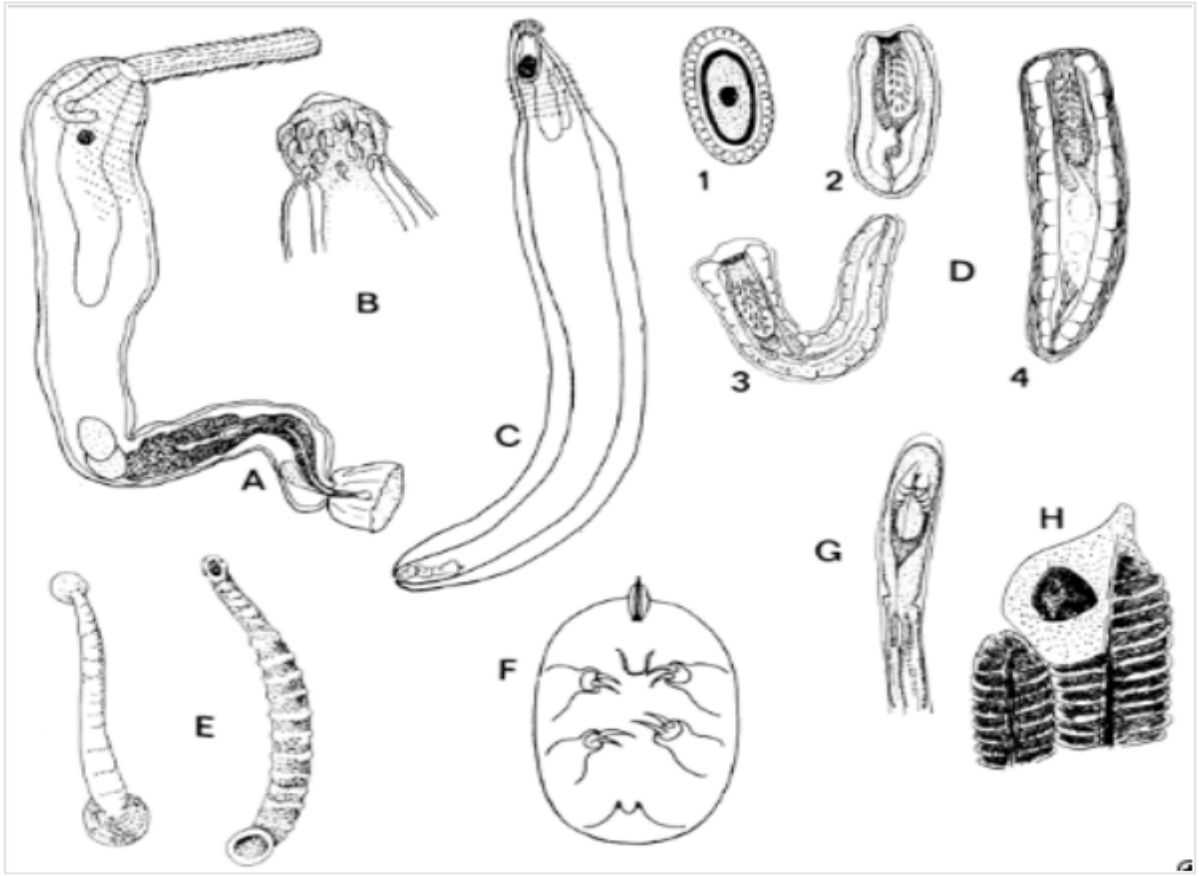
David Hughes.

Video!!

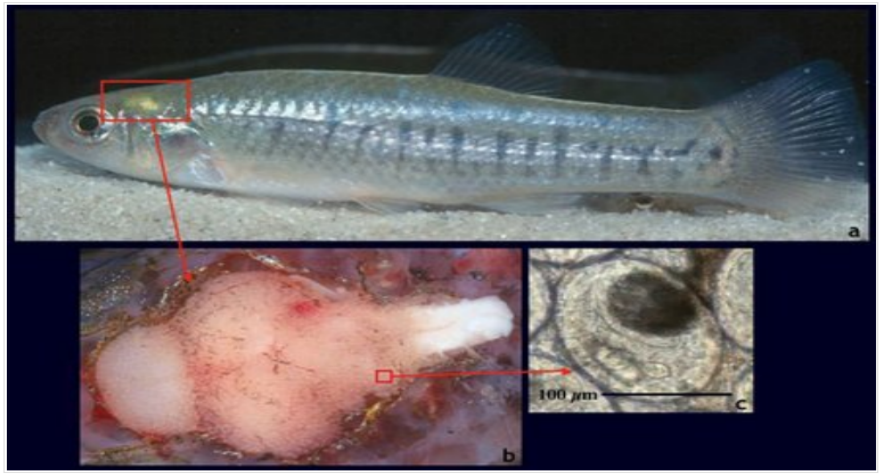


So many brains, so little time

http://www.mentalfloss.com/blogs/archives/25520
http://www.mentalfloss.com/blogs/archives/25336

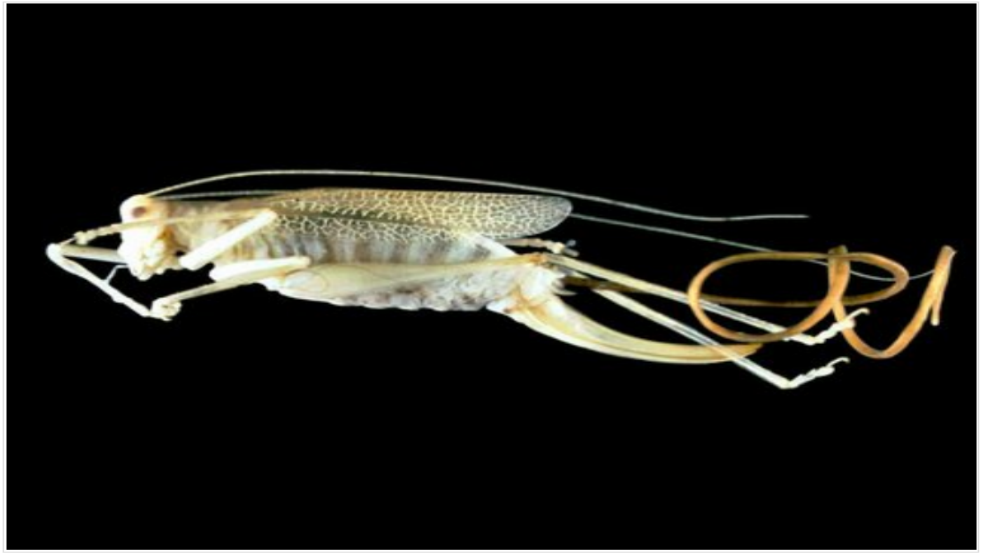


Thorny-headed worms (*Acanthocephala*) are 1150 species of parasite with hooks on their probosces (they don't have real mouths). They use these hooks to latch onto a victim. A couple of species target the crustacean *Gammarus lacustris*, or blue shrimp. Once inside, the worm changes the shrimp's chemistry, possibly affecting serotonin levels. The shrimp **loses interest in mating** and swims dangerously close to the surface. It will bite onto and cling to plants at the water's surface, which makes it easy prey for hungry ducks. When a ducks eats the shrimp, the thorny-headed worm has found its home. It lays its eggs inside the duck, completing its life cycle.



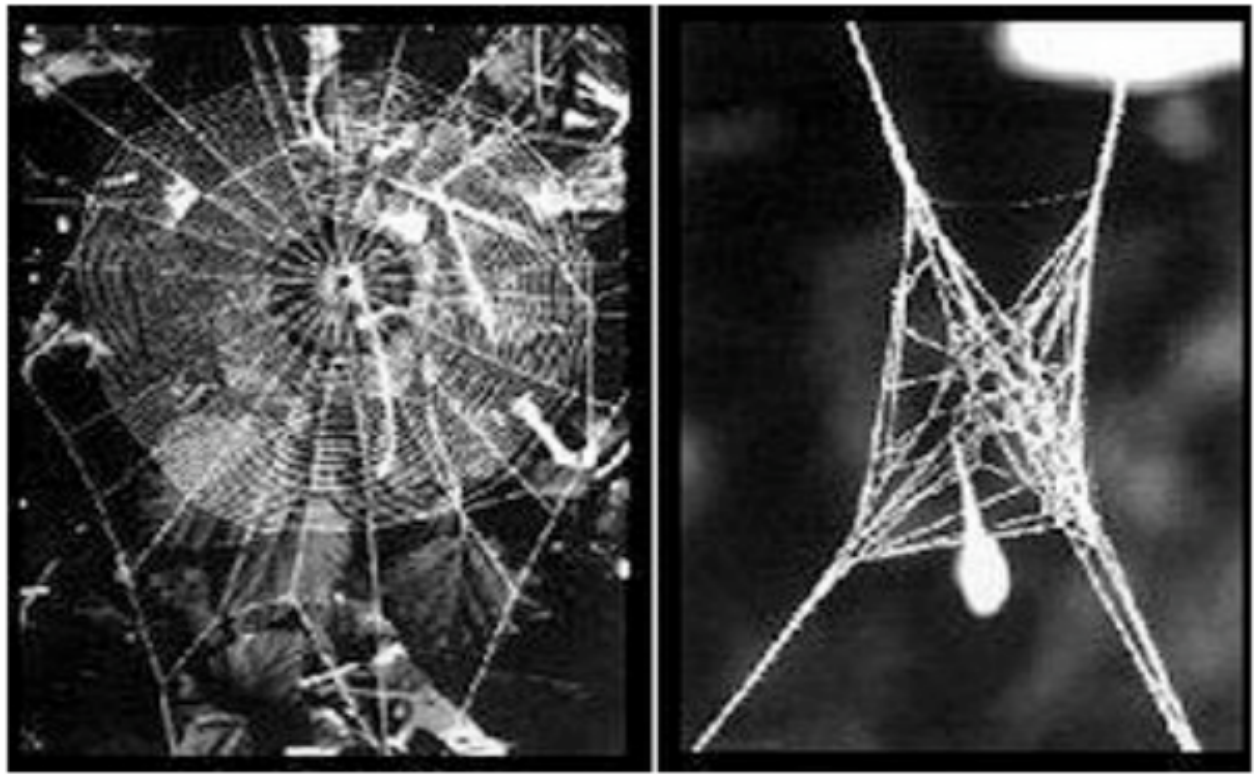
The parasitic worm ***Euhaplorchis californiensis*** infects three other species in a cycle, and alters the behavior of two of them. First, the eggs are consumed by horn snails. While living inside a snail, sometimes for several generations, *Euhaplorchis* inhibits the snail's **fertility**. The parasite will eventually leave the snail and infect the gills of a killifish. The worms will surround the fish's brain and cause it to swim near the surface and wiggle around. This makes the fish more likely to be eaten by a bird, which is what *Euhaplorchis* wanted in the first place. The digestive system of a bird is where the worm lays its eggs, which are excreted onto the beach where snails can reach them.

The flatworm ***Leucochloridium paradoxum*** infects two different animals in its lifetime, but only controls one of them. It lives its adult life inside birds and its eggs are spread by bird excretion. How does it get inside the birds? That's the horror story. Amber snails eat the eggs, which hatch in the snail's digestive tract. The larva changes into **sporocysts** (or broodsacs), which elongate and invade the snail's tentacles atop its head. The broodsacs, filled with hundred of *Leucochloridium paradoxum*, pulsate and seek light. The snail is helpless to retract its tentacles, and has lost its ability to perceive light and therefore does not hide. The inflated tentacles move like worms, attracting birds that **bite off the tentacles**. The flatworms then develop into the adult stage inside the bird. The snail, however, is left to die -or to undergo **the process again**.



The parasitic hairworm ***Spinochordodes tellinii*** is deadly to grasshoppers. Once eaten by a grasshopper or cricket, the larval worm produces **proteins** that affect the insect's brain and nervous system. By the time the worm reaches adulthood, the insect is completely under its power. The zombie grasshopper commits suicide by jumping into water, where the worm will emerge and look for a mate.

Cordyceps unilateralis infects ants for travel purposes in order to spread its spores. Oh, it eats them, too, but first the fungus will enter the brain and alter the ant's behavior over several days, making it climb to the top of a blade of grass. The ant will bite the grass for a secure hold. Only then will the fungus kill the ant and explode out of the head. The spores are then borne on the wind to parts unknown. See a **video** of Cordyceps in action.



Hymenoepimecis argyraphaga is a parasitic wasp found in Costa Rica. It infects one particular spider species, *Plesiometa argyra*. An adult wasp lays an egg on the spider's abdomen. When it hatches, it attaches itself to the spider and sucks its blood. When the right time comes, it releases a chemical into the spider that causes it to spin a web unlike any it would naturally spin. This web is designed to protect the wasp instead of feeding the spider. When the web is ready, the wasp larvae will kill the spider, eat it, and set up a cocoon in the safety of the web the spider build under the wasp larva's control.

Toxoplasma gondii is a protozoa that is normally parasitic to cats, but can survive in other species of mammals or birds, including humans. It causes the disease **Toxoplasmosis**, which is usually mild or even asymptomatic in humans, but can be dangerous for a fetus or those with compromised immune systems. *Toxoplasma gondii* affects the behavior of rats in a curious way -it makes them less afraid of, and even **friendly to cats!** Therefore, a rat with the infection is more likely to be eaten by a cat, which is the preferred victim as *T. gondii* reproduce inside cats. Does the parasite change **human behavior**, too?

> Some scientists believe that Toxoplasma changes the personality of its human hosts, bringing different shifts to men and women. Parasitologist Jaroslav Flegr of Charles University in Prague administered psychological questionnaires to people infected with Toxoplasma and controls. Those infected, he found, show a small, but statistically significant, tendency to be more self-reproaching and insecure. Paradoxically, infected women, on average, tend to be more outgoing and warmhearted than controls, while infected men tend to be more jealous and suspicious.

How this benefits the parasite is anyone's guess, but it may be chemically linked to the way *T. gondii* has evolved to get from the rat to the cat.

So... back to our original question...

- Is it *possible* for an outside entity* to control the body and behavior of a higher order organism through direct manipulation of the nervous system?

* *Entity* here is meant to encompass any biological or technological system that is alien to the normal biological operation of the target organism.

Now... is it *achievable* using current science and advanced technology?

Electrical Brain Stimulation Timeline

1870: Eduard Hitzig and Gustav Fritsch electrically stimulated the brains of dogs

- demonstrated that certain portions of the brain were the centers of motor function.

1900: Fedor Krause was able to do a systematic electrical mapping of the human brain

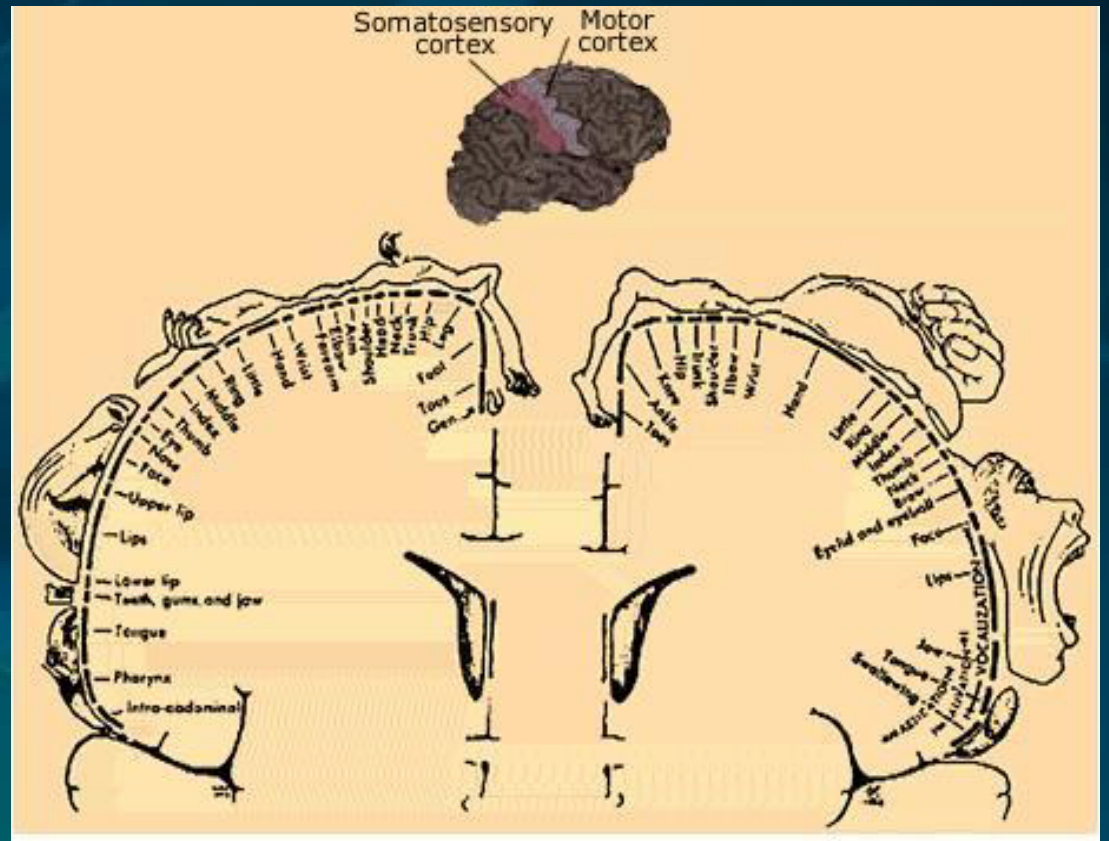
- used conscious patients undergoing brain surgery.

1930: Walter Rudolf Hess jolted patients' brains with shocks administered through tiny needles that pierced the skull.

- experiments included the insertion of fine electrically conductive wires into the brains of anaesthetized cats.
- given mild electrical stimulation the cats went "berserk."

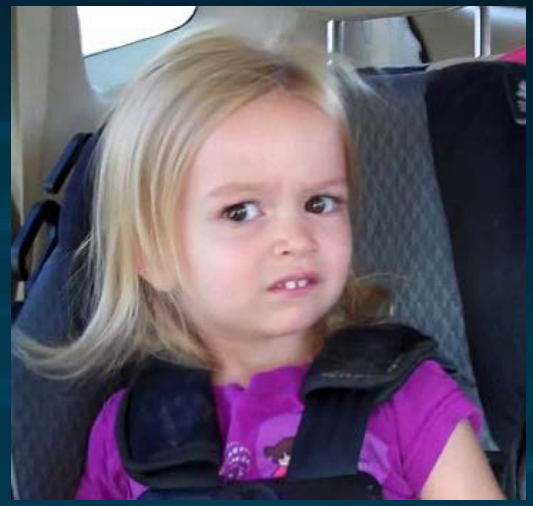
1940 – 1950: Wilder Penfield experimented with electrical brain stimulation on patients undergoing surgery.

- discovered that the application of electricity to alert patients could stimulate the memory of past events.



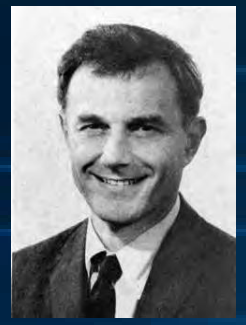
These famous brain maps by Wilder Penfield show that each part of the body is represented on two strips of the brain's cerebral cortex, the somatosensory cortex (left), which receives sensations of touch, and the motor cortex (right), which controls movements. Fingers, mouth, and other sensitive areas take up most space on both maps. Penfield called these cross sections the "sensory homunculus" and the "motor homunculus."

EBS Timeline



1950: Robert G. Heath and Dr. Russell Monroe,

- funding from the CIA and the DoD,
- implanted as many as 125 electrodes into subjects' brains,
- injected a wide variety of drugs directly into the brain tissue through small tubes;
  - including LSD, psilocybin, and mescaline.
- equipped dangerously aggressive mental patients with self-stimulators
  - film shows a patient working himself out of a violent mood by pushing the stimulator button



1956: James Olds

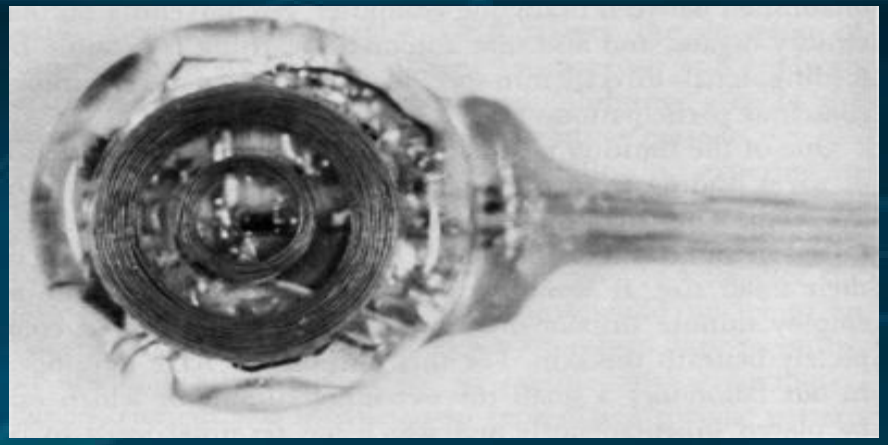
- Implanted electrodes in pleasure center of the brain of rats
- Attached a device that allowed the rats to activate the electrical impulse.
- Rats became so obsessed with self-stimulation that they would "literally starve themselves to death. "
- Very similar results have since been achieved replacing rats with monkeys.

1960: Enter Dr. Jose Delgado

Jose Delgado and Animal Experiments

Parts of Delgado discussion adapted from ES462 Presentation, [redacted] and [redacted]

The Stimoceiver



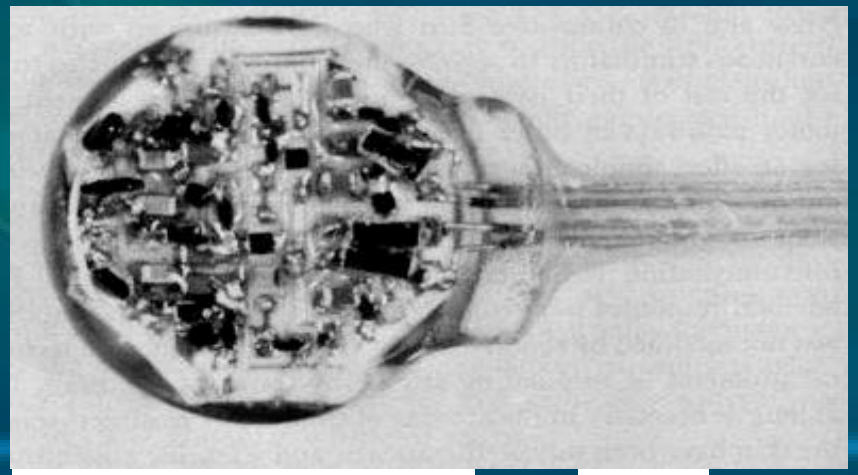
Stimoceiver, also called a transdermal stimulator.

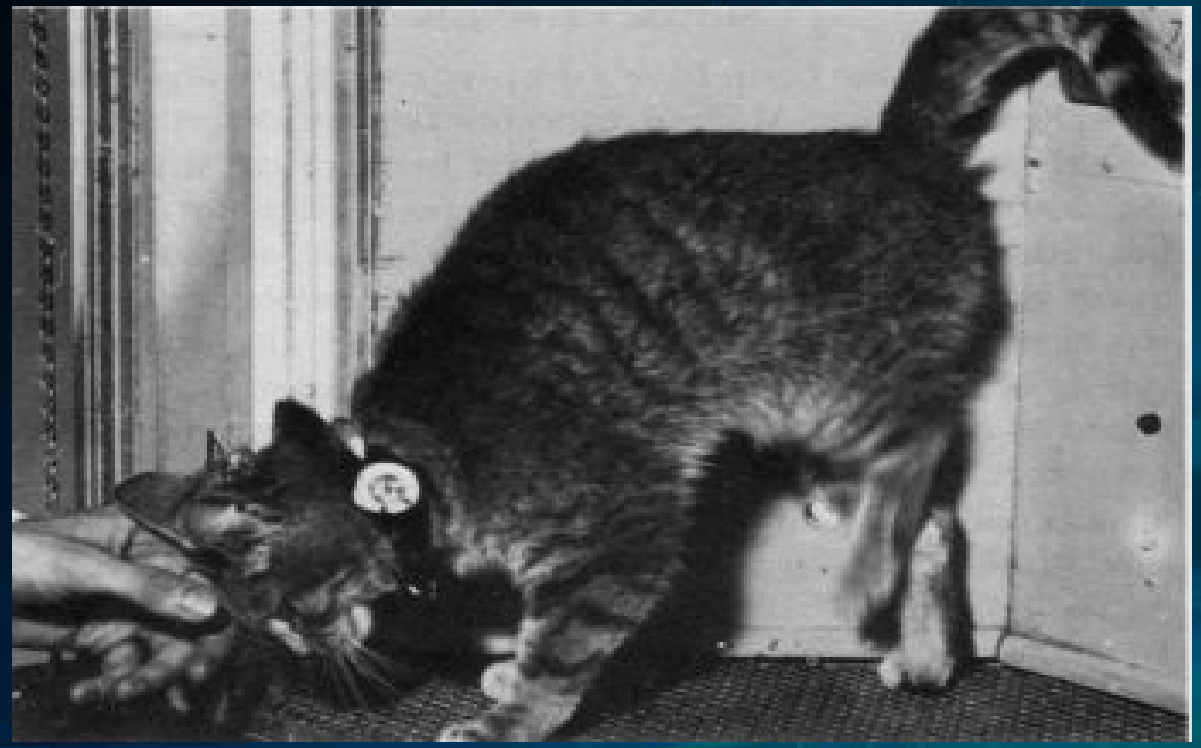
- no batteries

- activated by radio

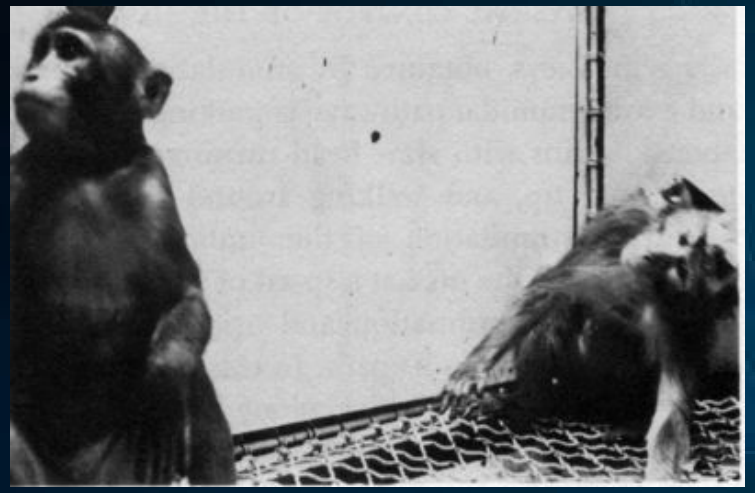
- can be used for life

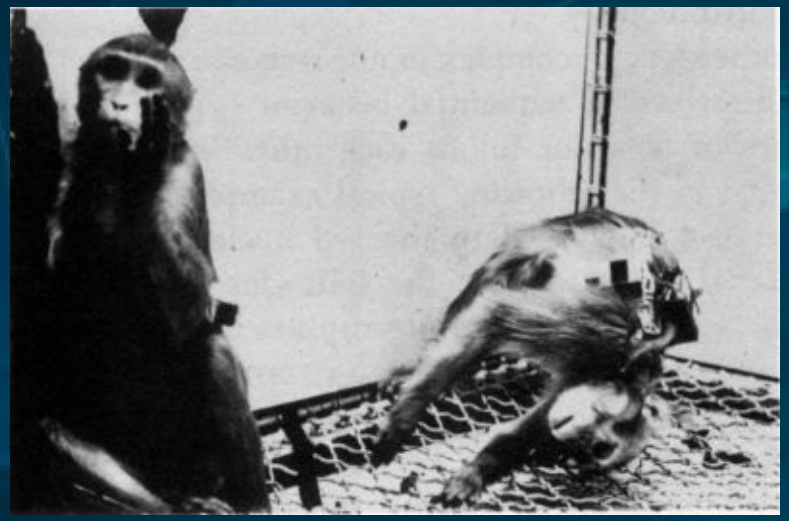
(brain can be stimulated indefinitely)

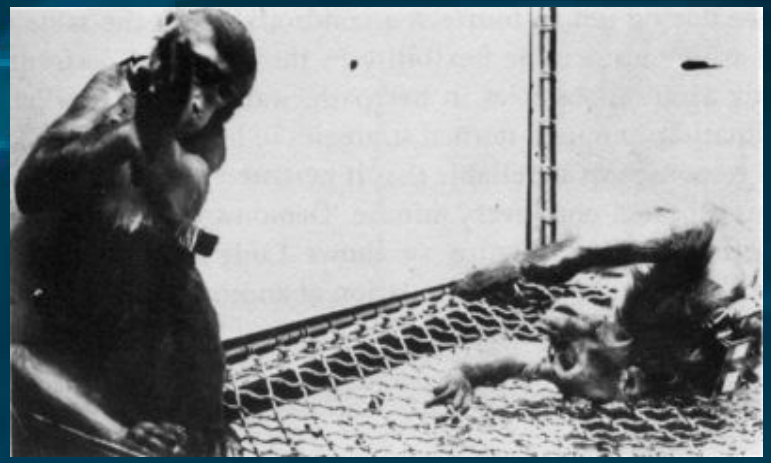




Electrical stimulation of the right-side motor cortex produced flexion of the left hind limb proportional in amplitude to the electrical intensity used.

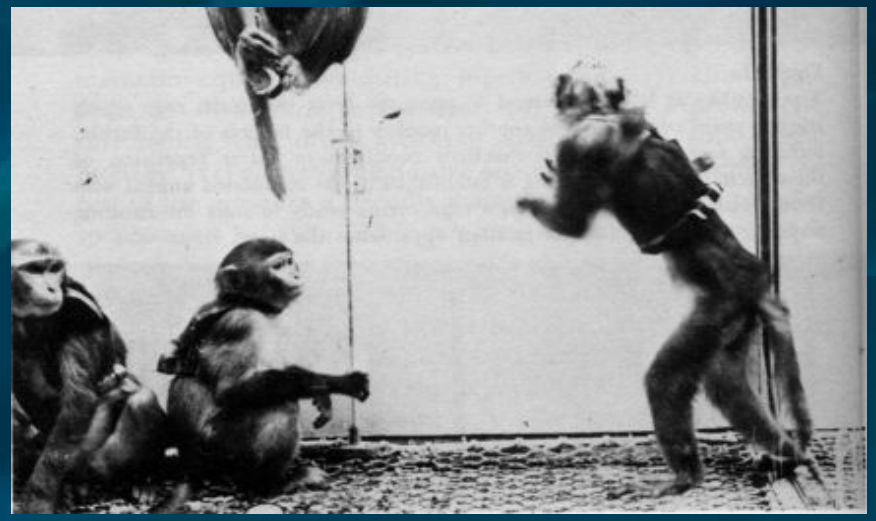


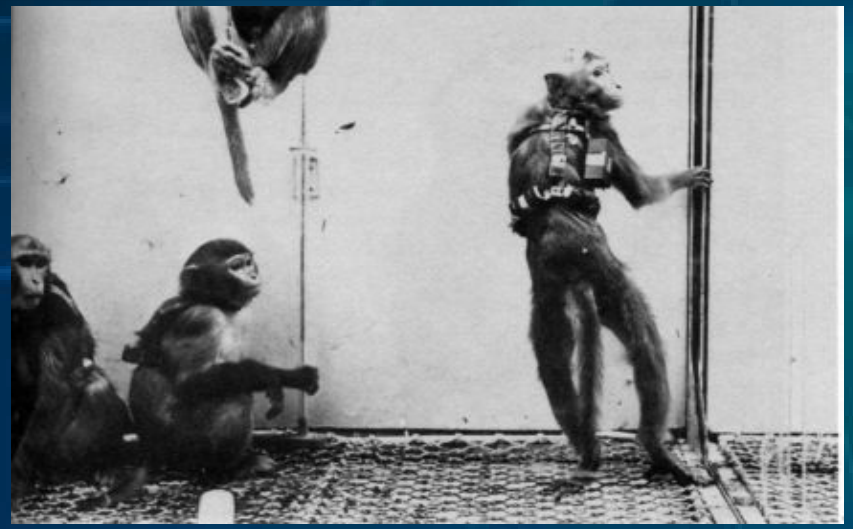


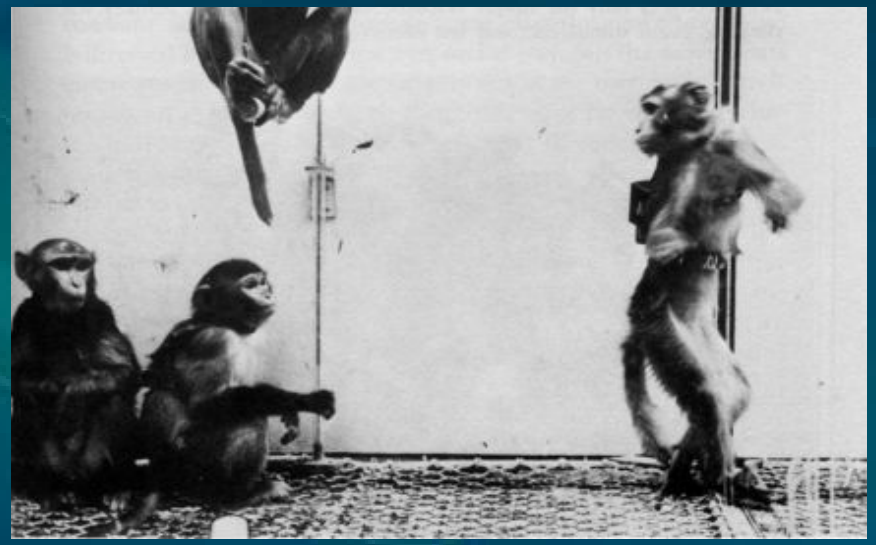


Progressive clockwise rotation of the body along the longitudinal axis with complete loss of equilibrium produced by radio stimulation of specific areas of the brain (in this case, the tectum).

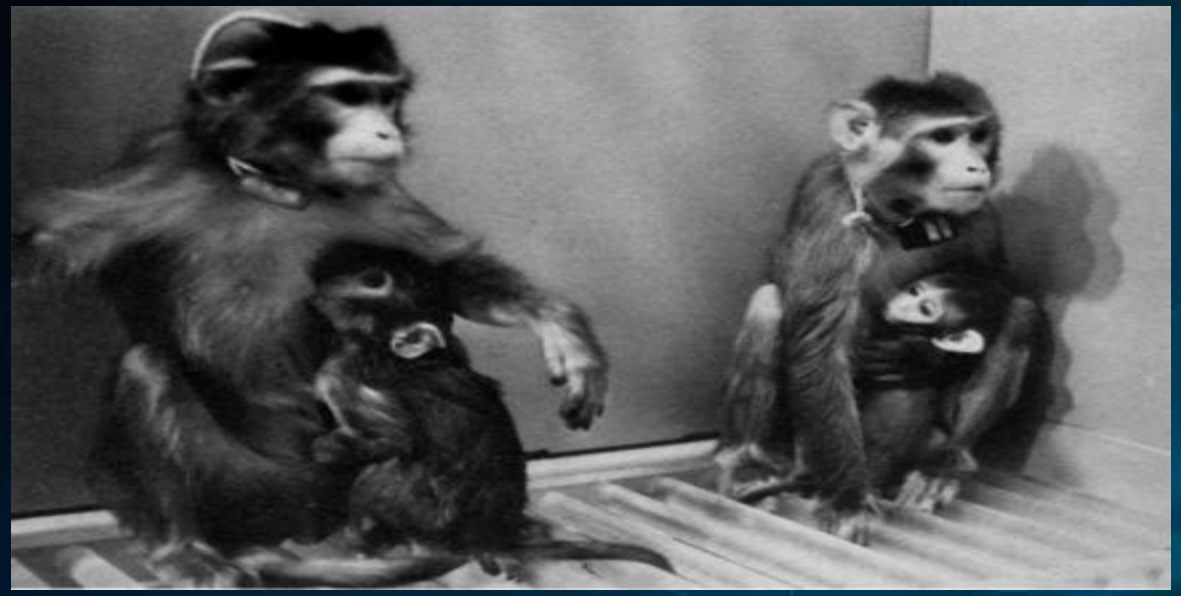
Stimulation of the red nucleus in monkey Ludy produced a response which included turning of the head, walking on two feet, turning around, and other sequential effects. The experiment was repeated more than 20,000 times with reliable performance.

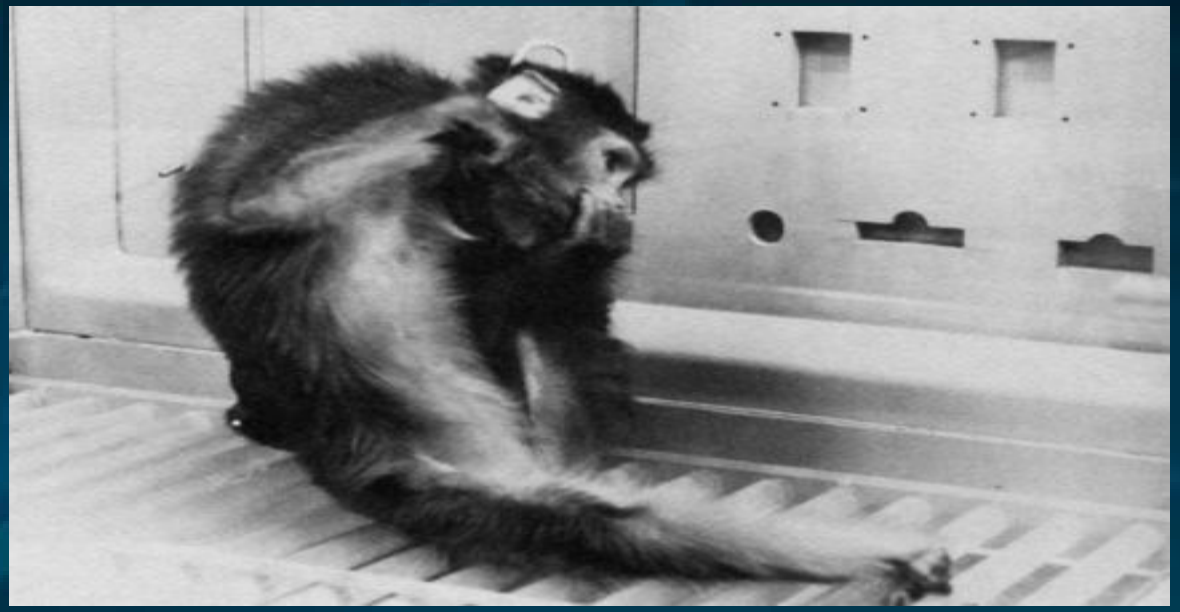


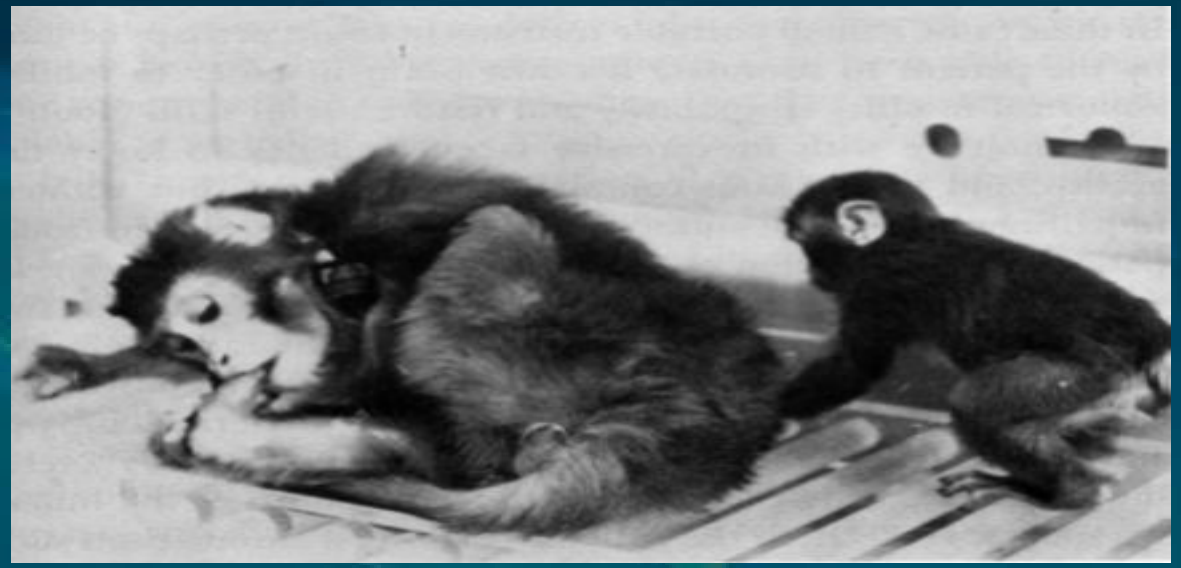




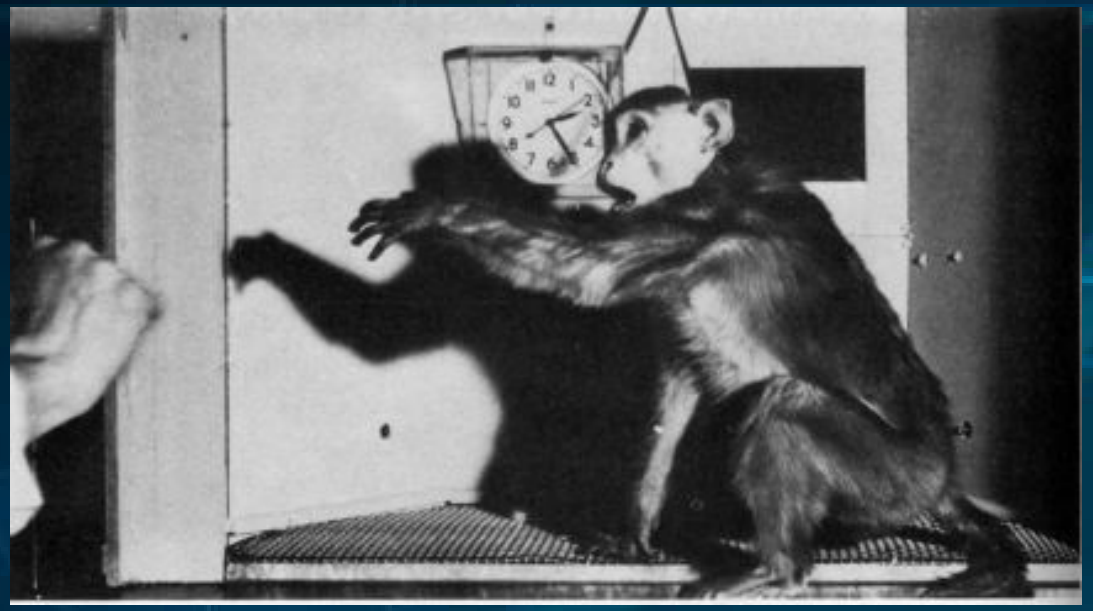
Radio stimulation of Ludy in another red nucleus point 3 millimeters away produces only the simple response of yawning.







Brain stimulation in mother monkey resulted in “loss of maternal instinct” Mother ignored child.

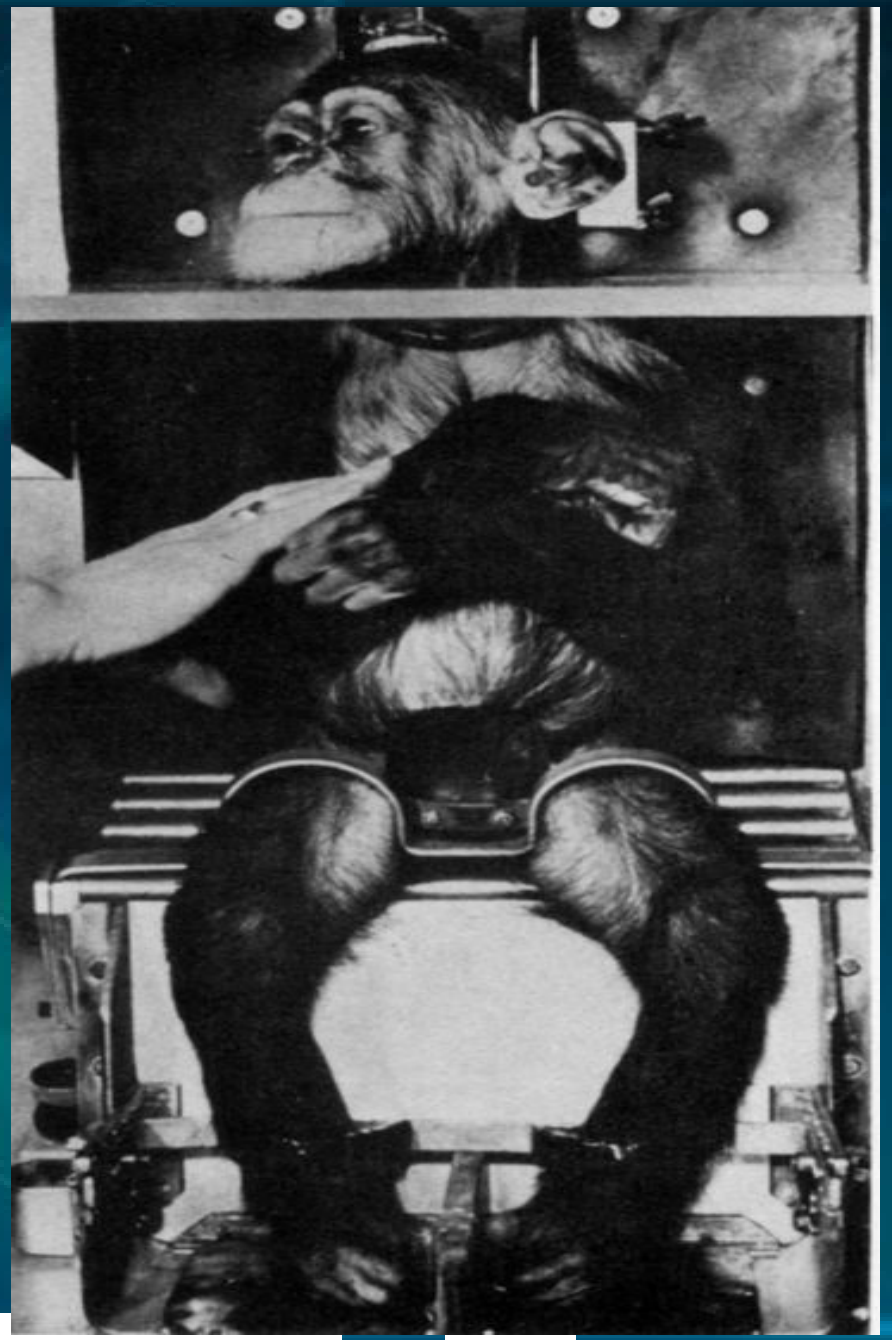


Rhesus monkeys are usually ferocious and will often launch attacks, trying to catch and bite the observers (above). This ferocity is inhibited during stimulation…

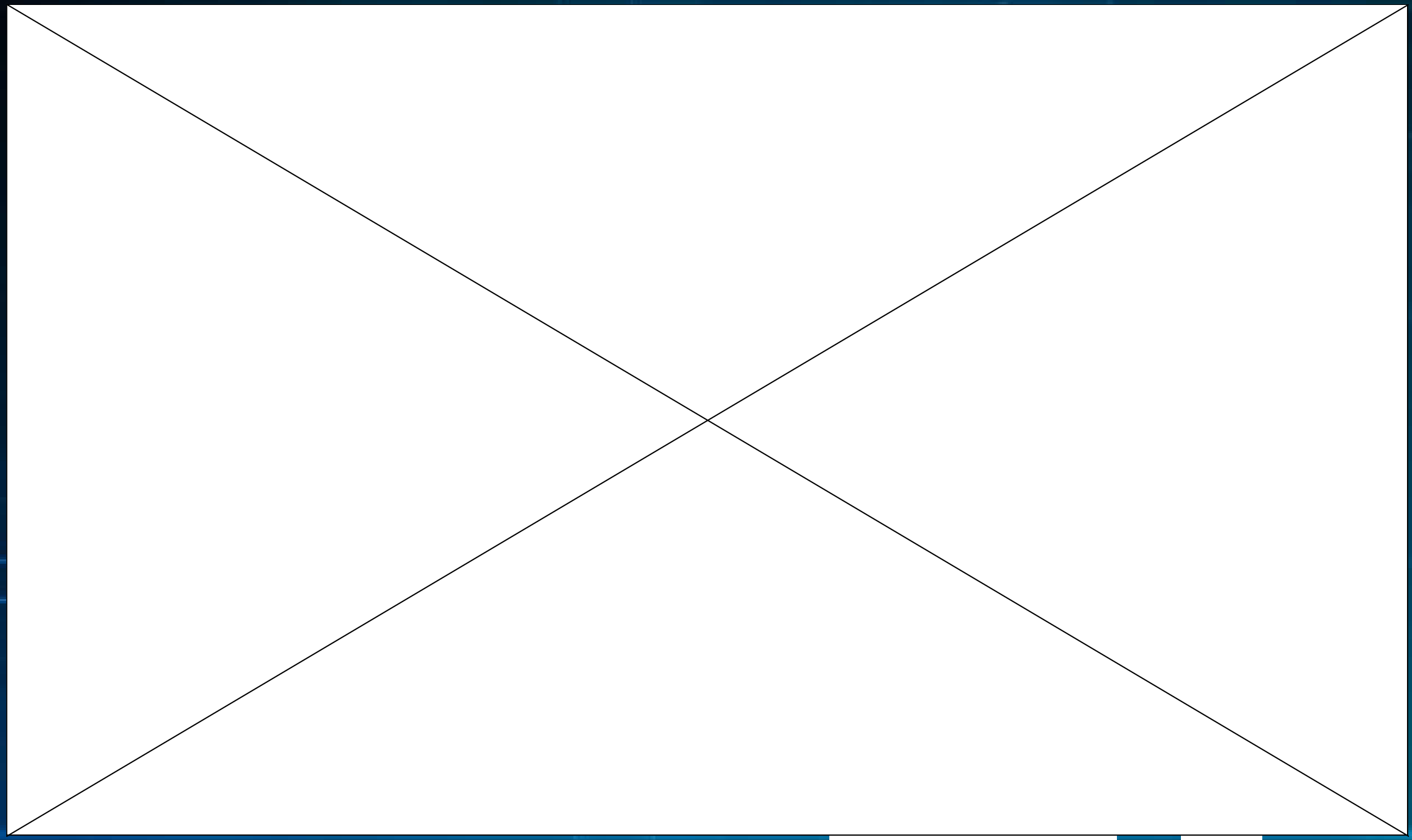
« Carlos »

Reacts with offensive-defensive manifestations when touched

<u>Claudate Stimulation</u> the chimpanzee is inhibited and can be teased without evoking any response.



Brave bulls are dangerous animals which will attack any intruder into the arena. The animal in full charge can be abruptly stopped (above) by radio stimulation of the brain.



EBS Gone Wild

- Delgado implanted electrodes in some 25 human subjects.
- Experimented on humans both the motor cortex (physical motions) and the limbic system (emotions).
- "Delgado limited his human research, however, because the therapeutic benefits of implants were unreliable; results varied widely from patient to patient and could be unpredictable even in the same subject."
- Delgado thought he was on the verge of "conquering the mind" and creating "a less cruel, happier, and better man."

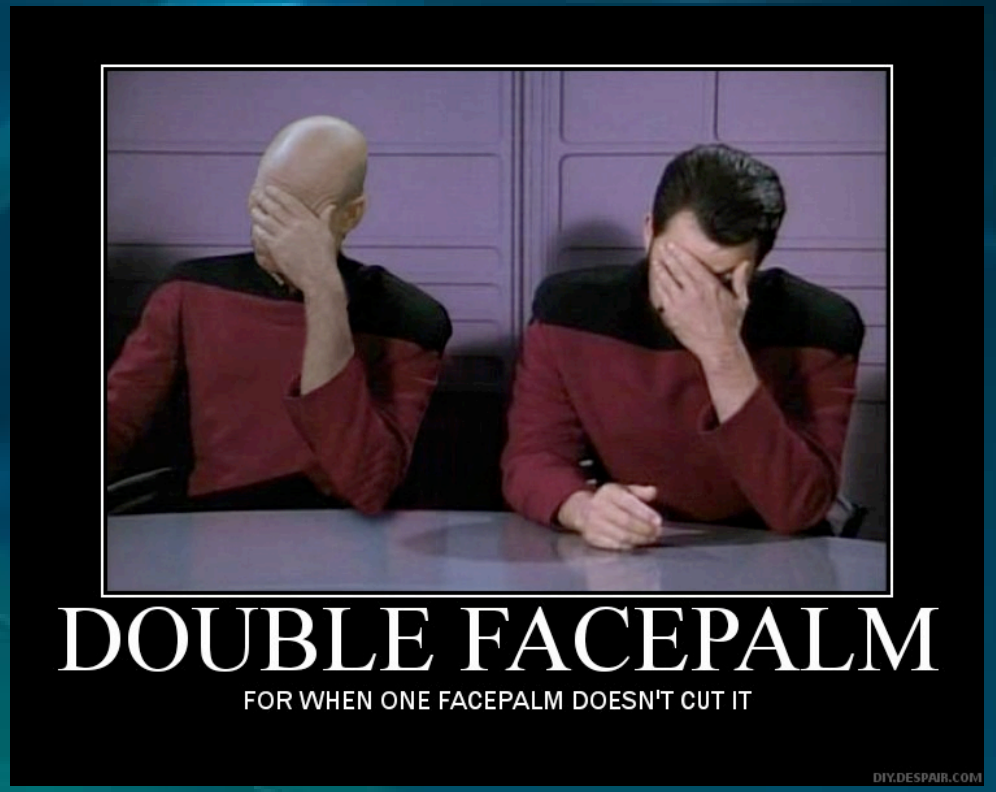
Outed

In **1970**, a scandal was triggered by Frank Ervin and Vernon Mark, two researchers at Harvard Medical School

- One of Ervin's students was Michael Crichton, who wrote *The Terminal Man.*
- In their book, *Violence and the Brain,* Ervin and Mark suggested that brain stimulation or psychosurgery might quell the violent tendencies of "blacks rioting in inner cities."

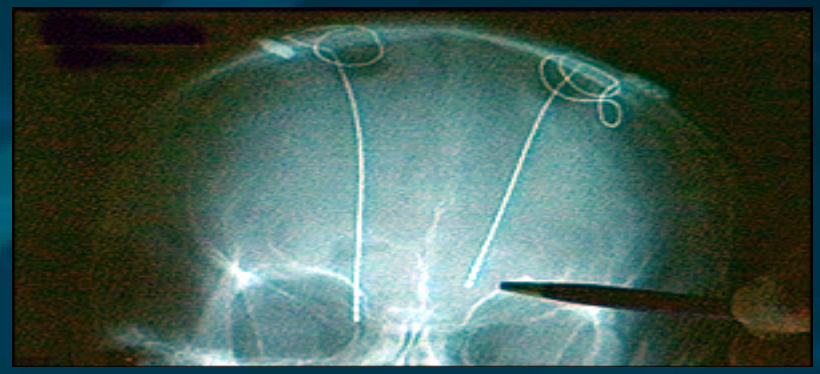
In **1972** Heath, the Tulane psychiatrist, raised more questions about brain-implant research

- tried to change the sexual orientation of a male homosexual
- Stimulated the man's septal region while subject had intercourse with a female prostitute



EBS in Clinical Use

- Deep Brain Stimulation is a common technique for counteracting debilitating diseases such as:
  - Parkinson's disease (FDA approval in 2002)
  - Dystonia (FDA approval in 2003)
  - Tourette's syndrome
  - Clinical depression
  - Etc.



- A wire carrying four tiny electrodes is inserted deep inside the [area of the] brain … which is responsible for controlling movement.

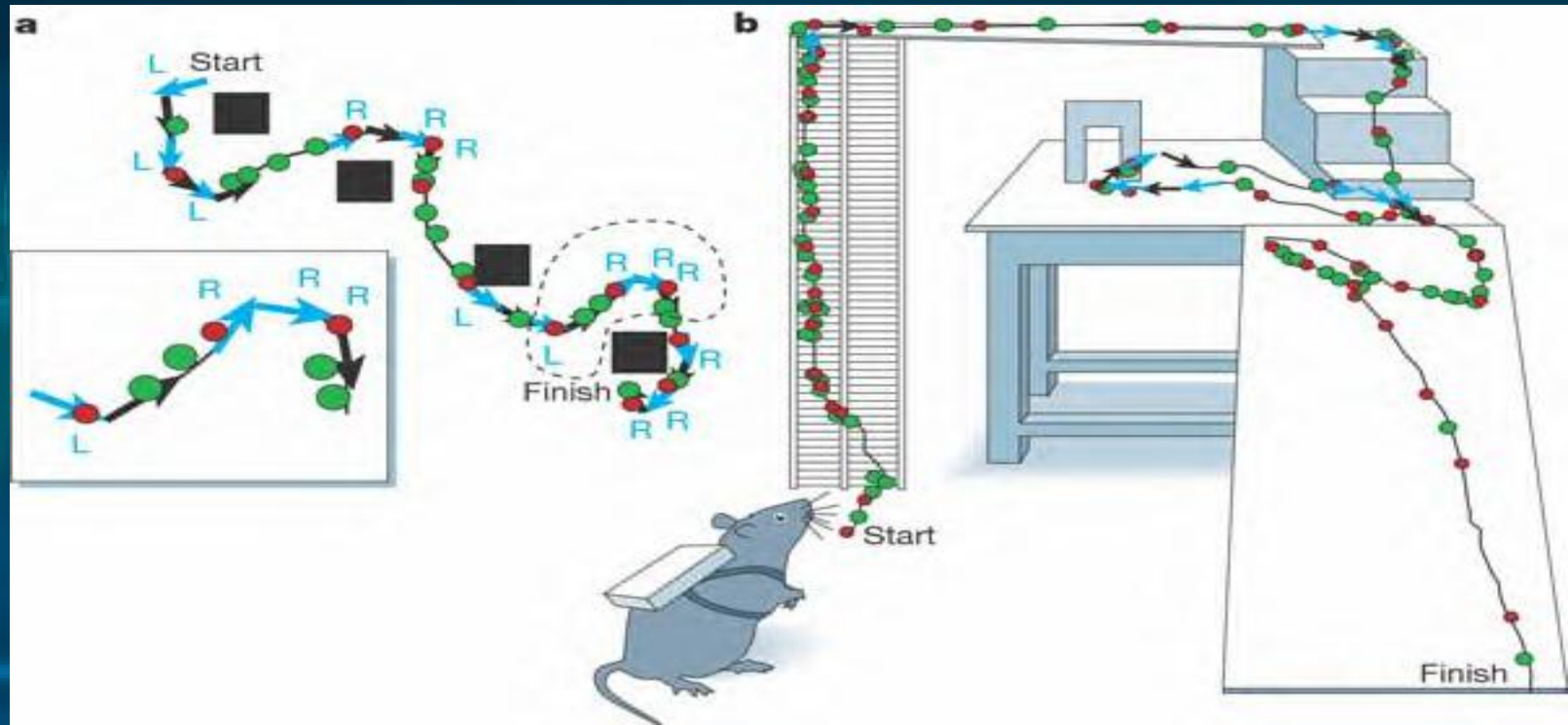
- A battery operated pulse generator is implanted beneath the collarbone… The patient then controls the device by switching it on or off with a handheld magnet

- Depending on where the brain implant is located, the pulses will block the signals that cause symptoms of the disease.

EBS in Animal Studies

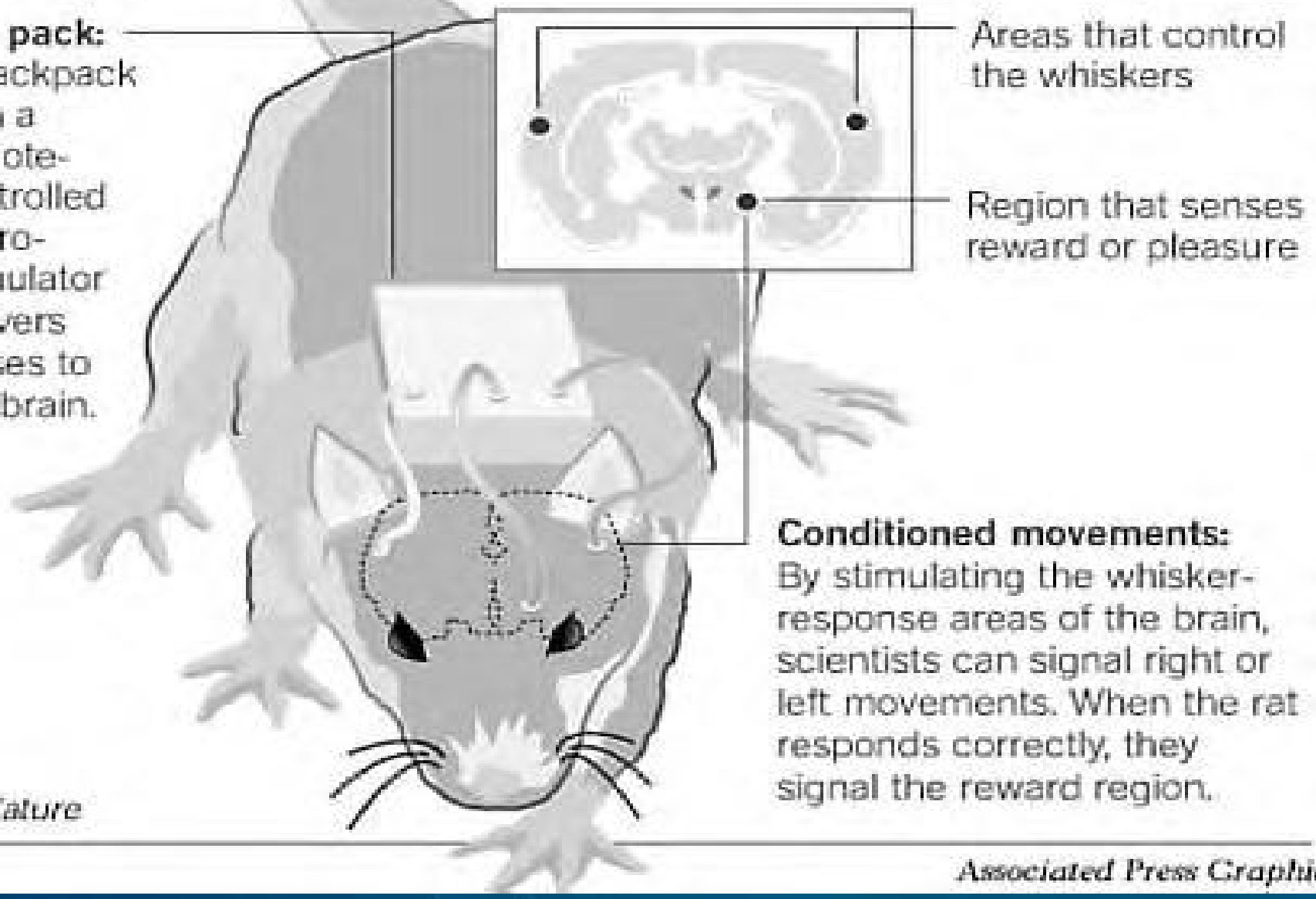
In the wake of 9/11, researchers scrambled to develop robots that could perform USAR

Rats…



Rat-ical innovation for remote rescue

Remote-controlled rats could be an important new aid for search and rescue teams.

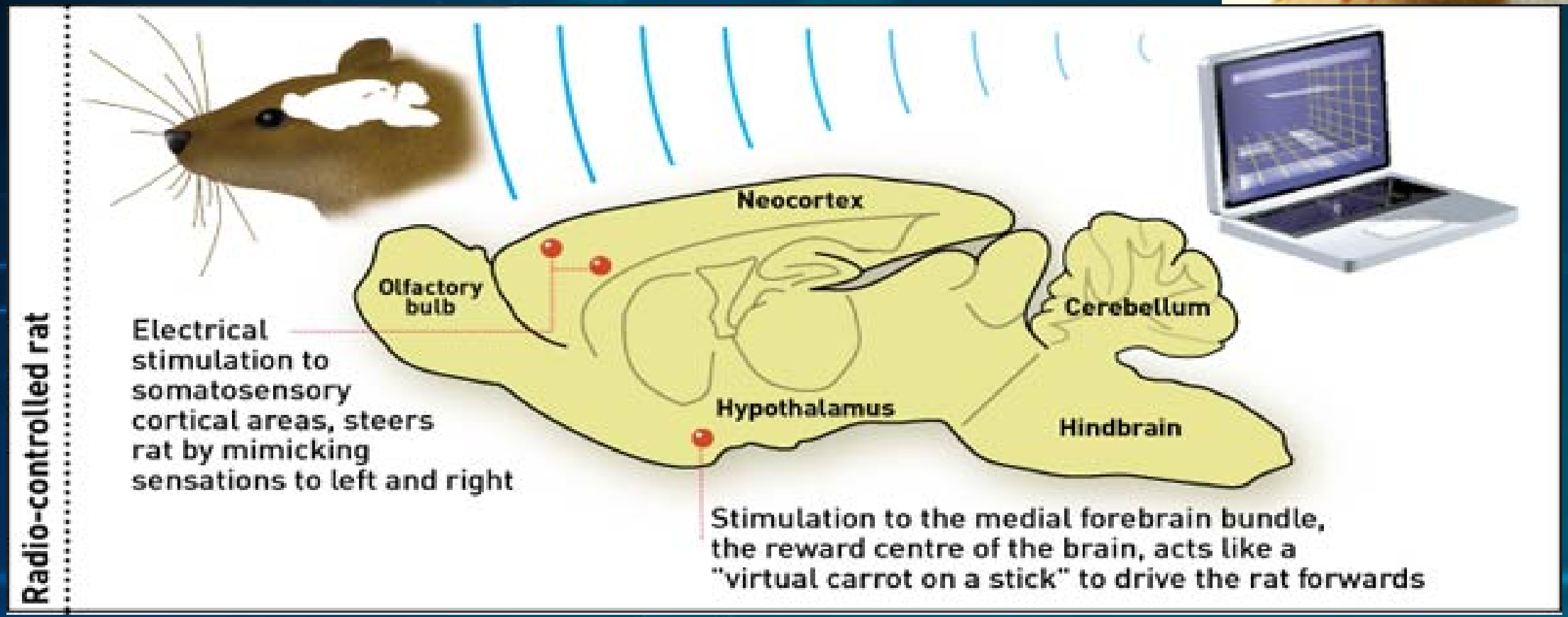


Source: Nature

Associated Press Graphic

How to Wire It

Follow these easy steps...



More...

Light-controlled nematode worm

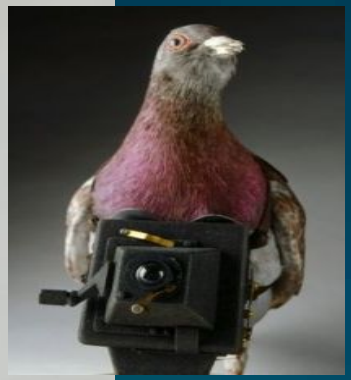
light-responsive algae implanted into neurons
Worm moves based on color of light

http://www.eurekalert.org/pub_releases/2005-12/cp-api121305.php

The future?

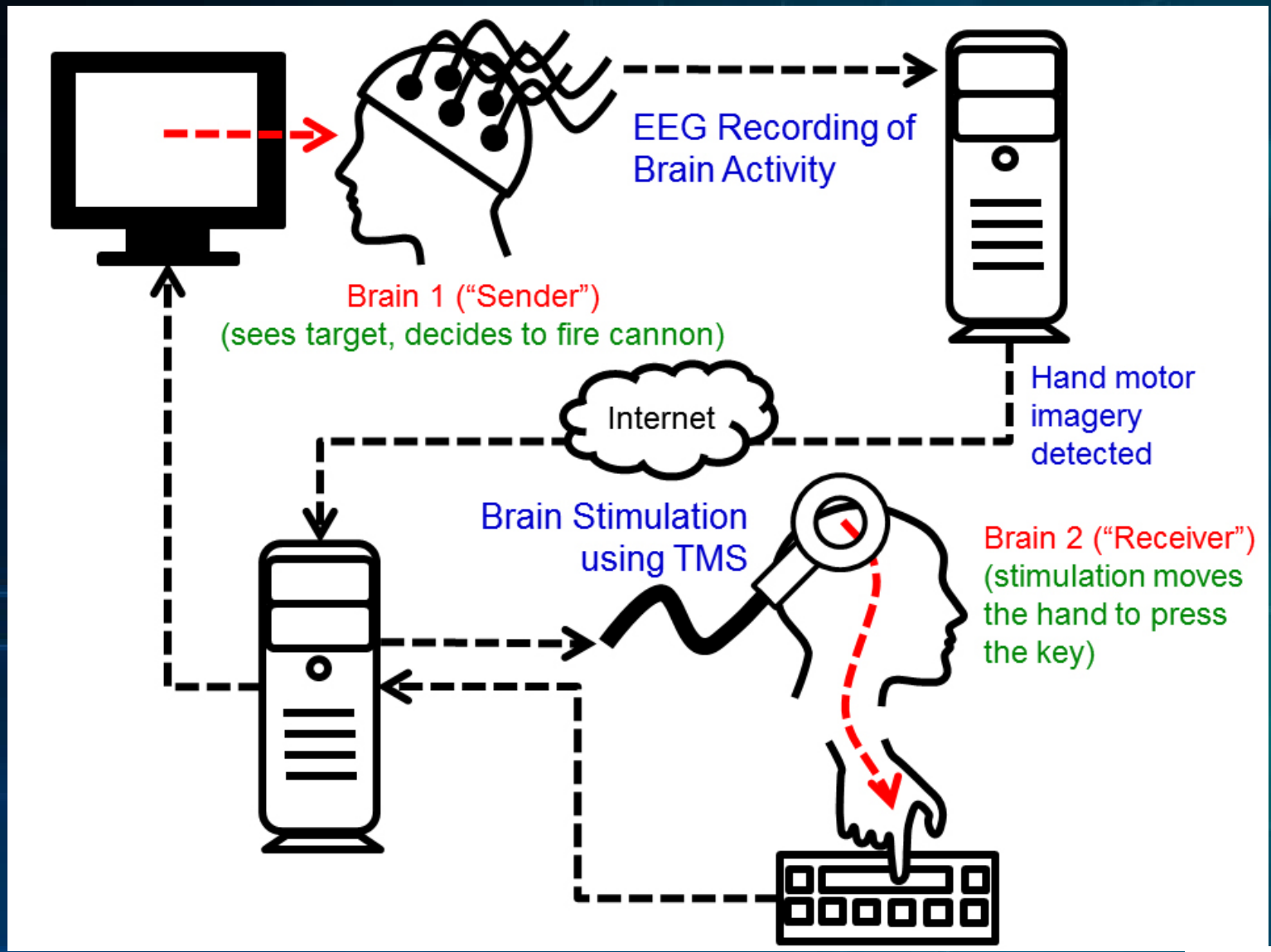
http://www.dailytech.com/US+May+Use+Stealth+Sharks+to+Patrol+Seas/article1067.htm

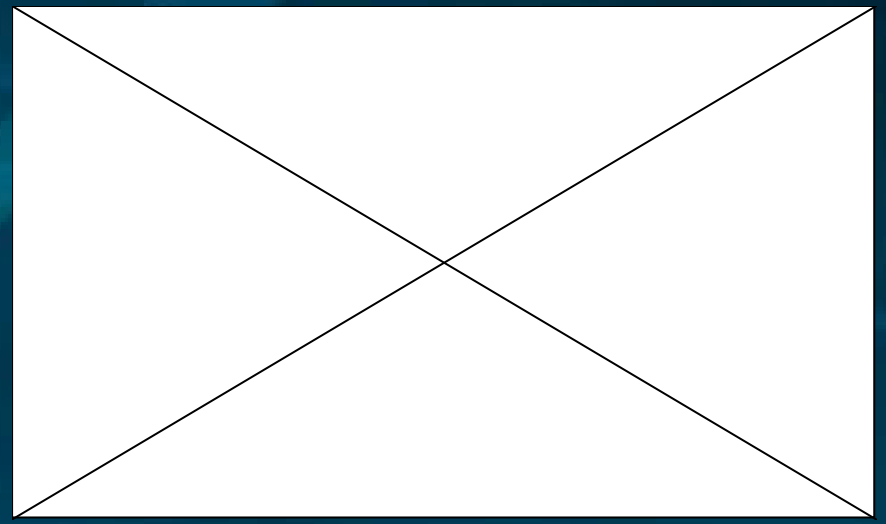
http://blog.wired.com/defense/2007/02/cyborg_flying_r.html

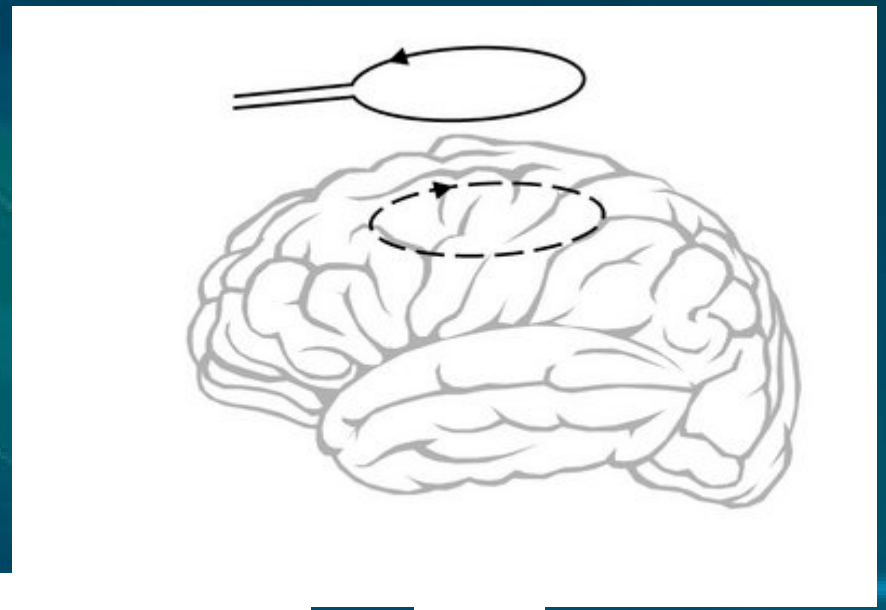


Remote controlled pigeon (China)

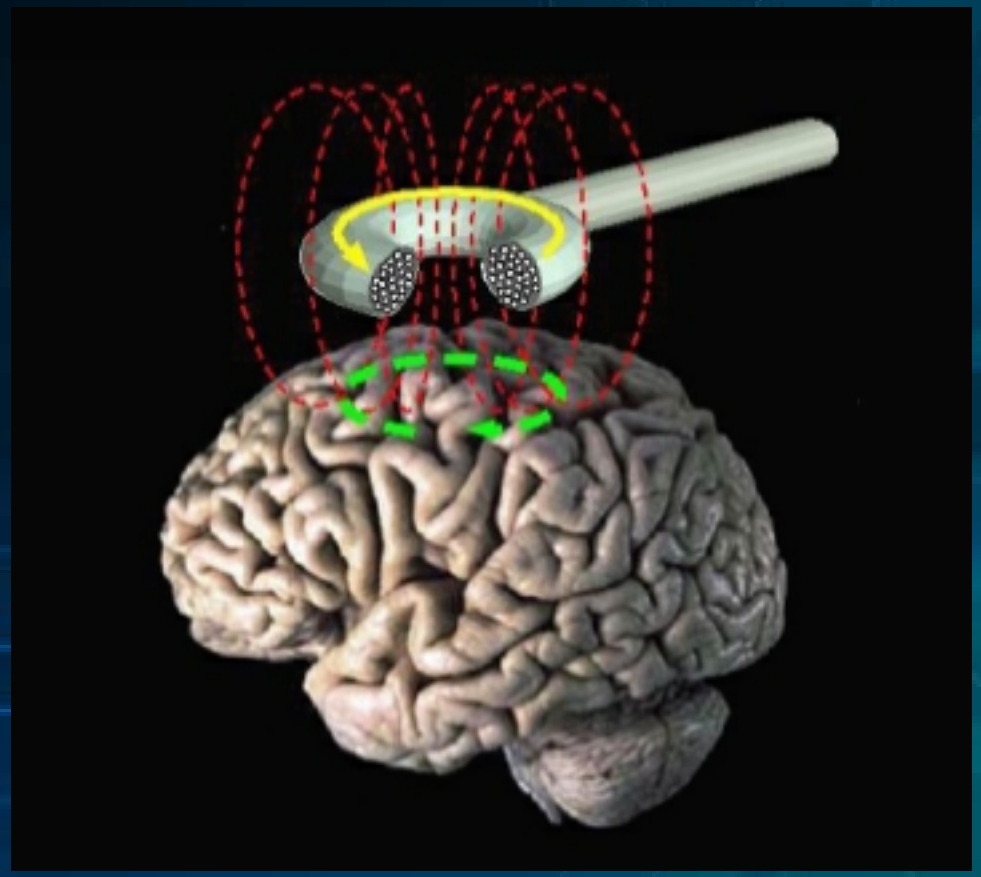
Without Brain Surgery?







Clinical Use of TMS



FDA approved for treatment of depression and migraines

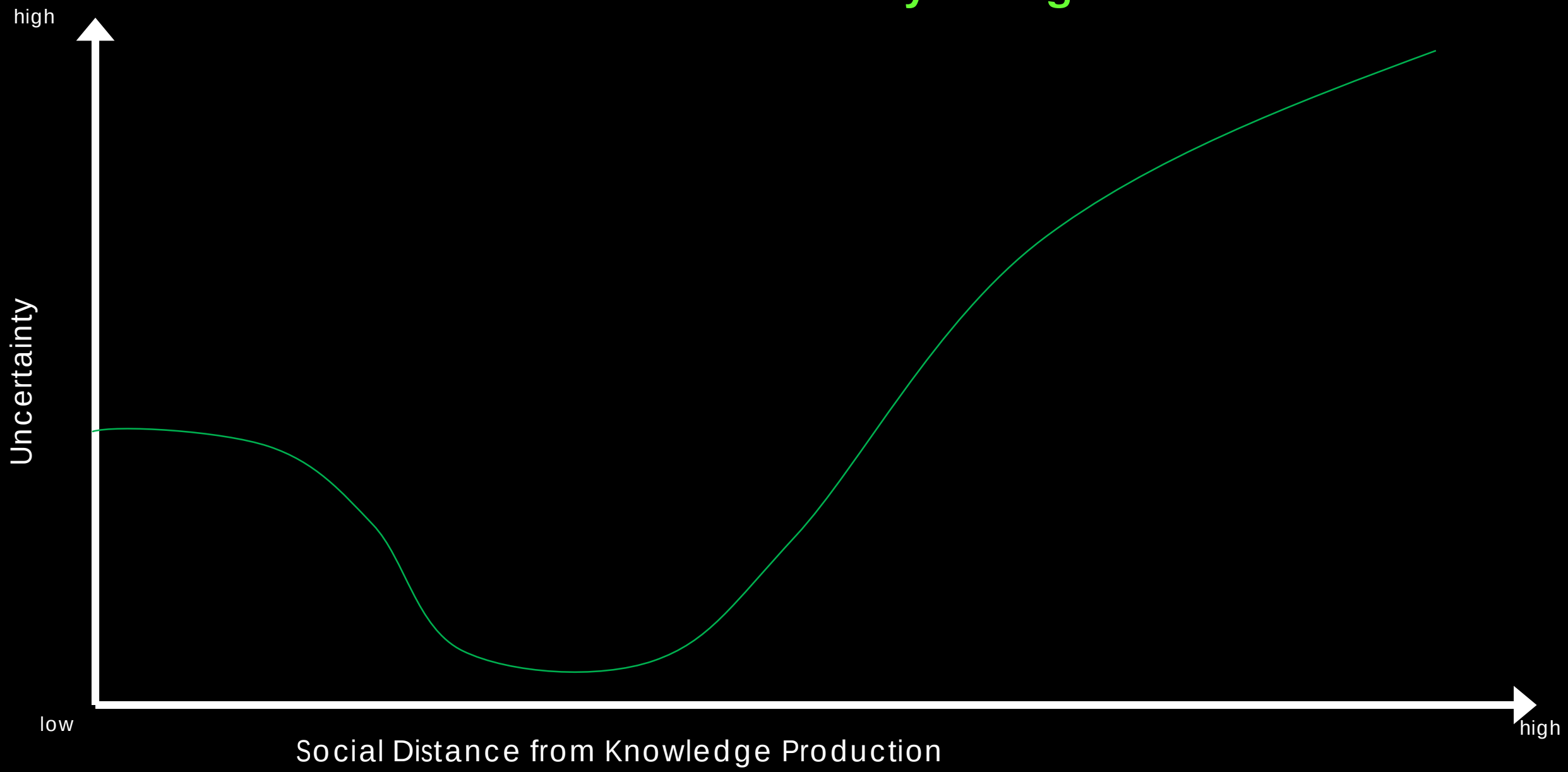
Studies undeway to *treat* “brain death, coma, and other persistent vegetative states”

Lefaucheur, JP; et al. (2014). "Evidence-based guidelines on the therapeutic use of repetitive transcranial magnetic stimulation (rTMS)". *Clinical Neurophysiology*. **125** (11): 2150–2206.

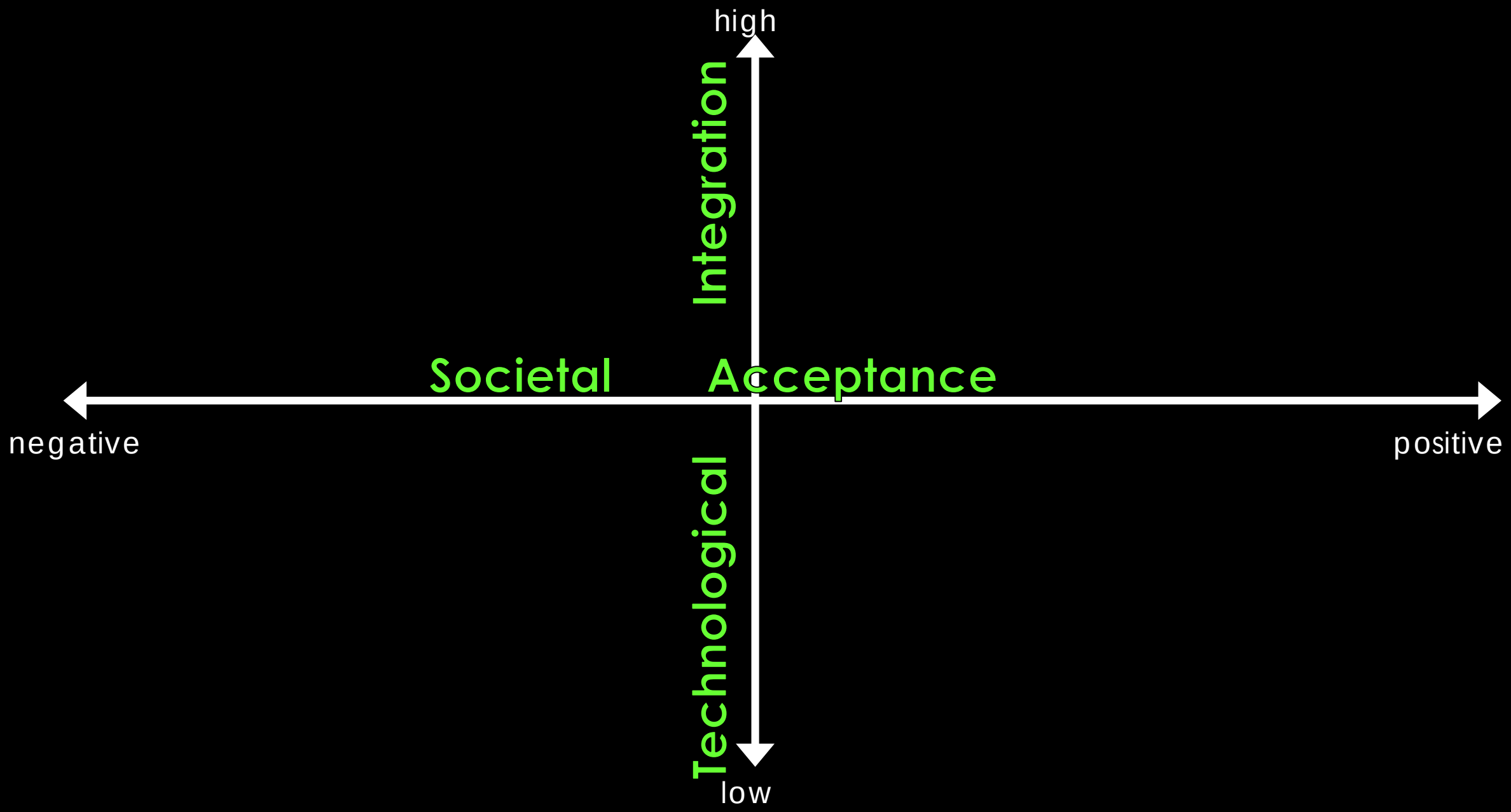
Sociotechnological Development

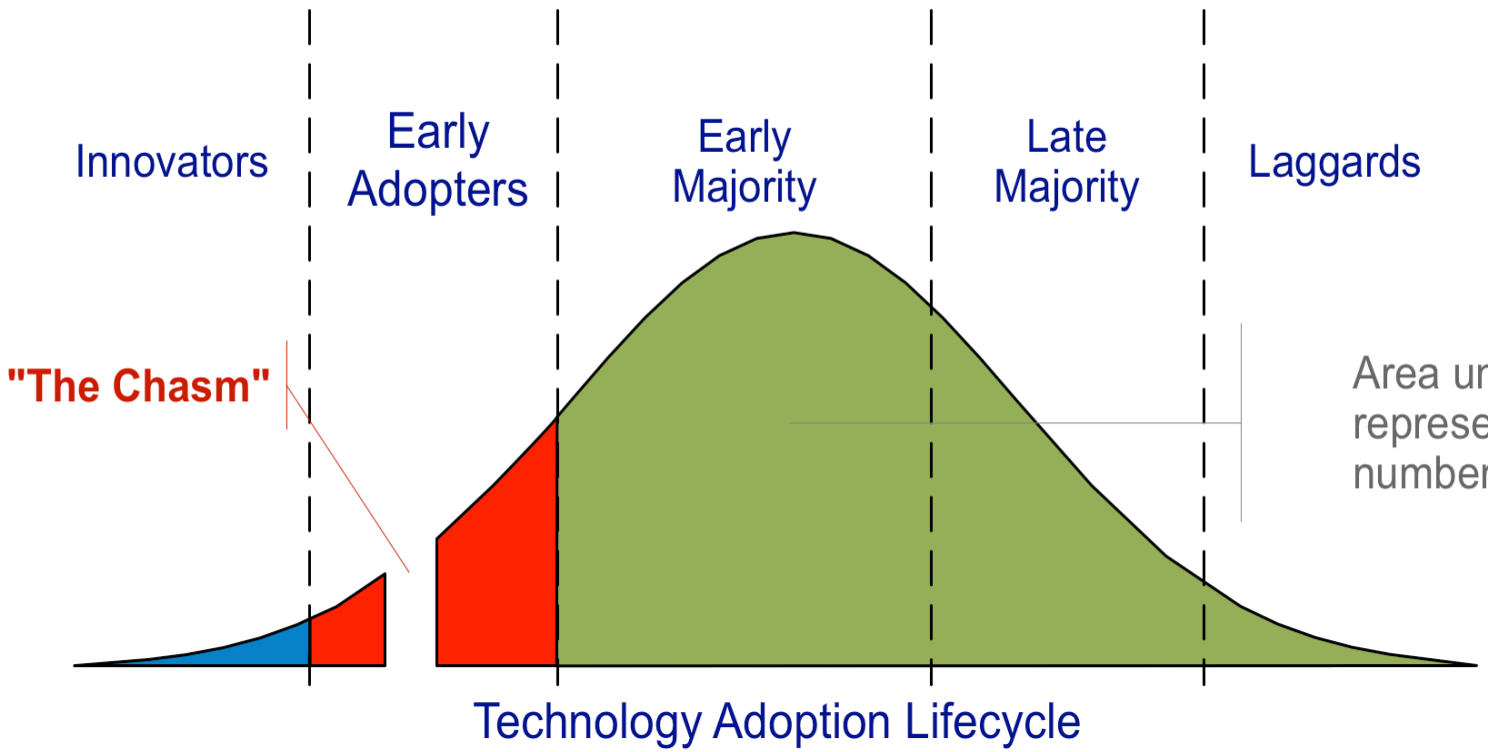
- What are the important questions?
- Which tools are useful in this analysis?

McKenzie's Uncertainty Trough

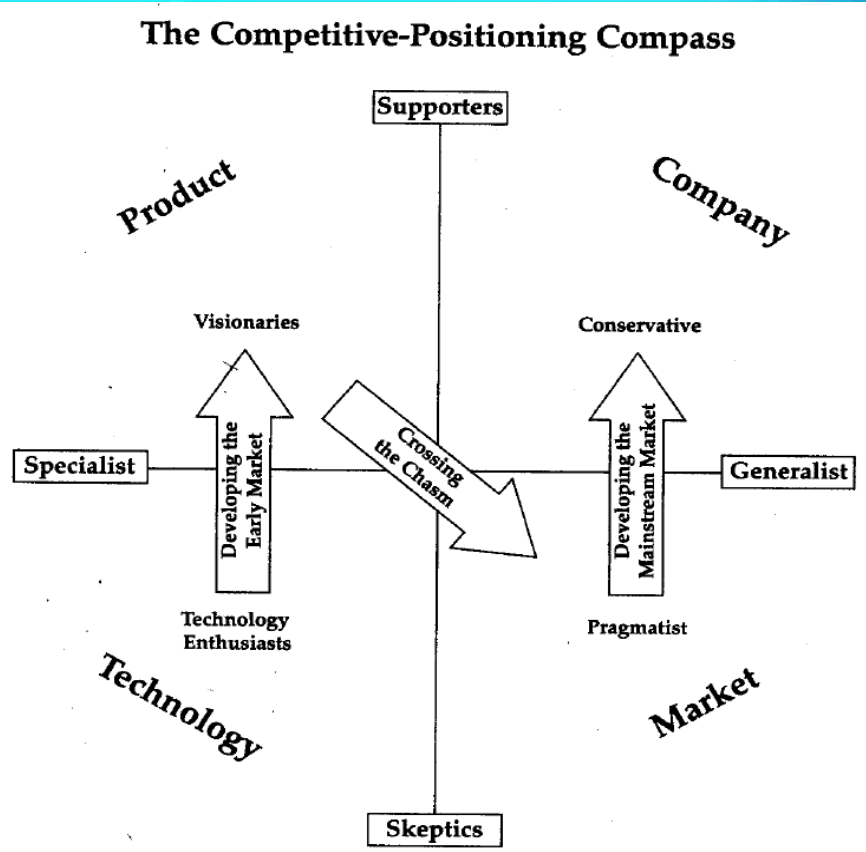


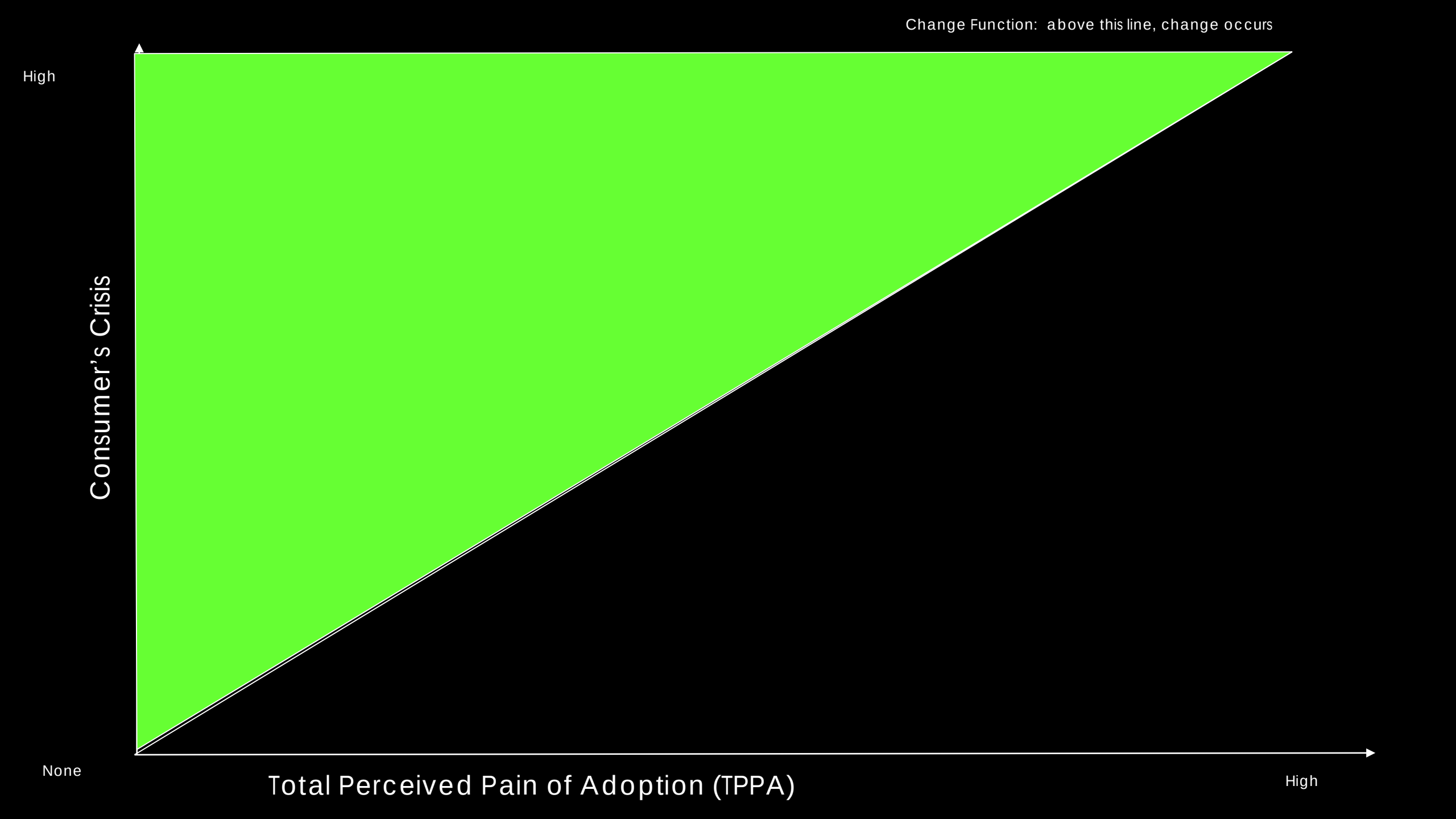
Sager's Technological Integration Coordinates





Area under the curve represents number of customers




Change Function: above this line, change occurs
High
Consumer's Crisis
None
Total Perceived Pain of Adoption (TPPA)
High